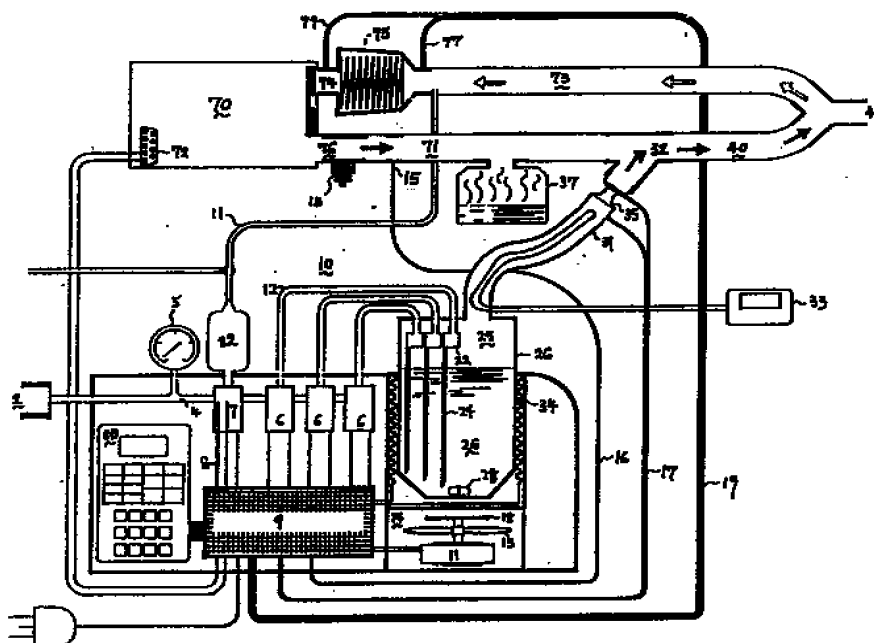




INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification ⁵ : A61M 15/00, 16/10, A62B 7/00 F16K 31/02	A1	(11) International Publication Number: WO 92/12750 (43) International Publication Date: 6 August 1992 (06.08.92)
(21) International Application Number: PCT/US92/00566 (22) International Filing Date: 22 January 1992 (22.01.92) (30) Priority data: 645,579 24 January 1991 (24.01.91) US (71) Applicant: VORTAN MEDICAL TECHNOLOGY, INC. [US/US]; 3941 J Street, Suite 354, Sacramento, CA 95819-3633 (US). (72) Inventors: RAABE, Otto, G. ; 652 Buchanan Street, Davis, CA 95616 (US). LEE, James, I., C. ; 7861 Rush River Drive, Sacramento, CA 95831 (US). HATHAWAY, James, Calvin ; 441 Hartnell Place, Sacramento, CA 95825 (US).		(74) Agents: YIN, Ronald, L. et al.; Limbach & Limbach, 2001 Ferry Building, San Francisco, CA 94111 (US). (81) Designated States: AT (European patent), AU, BE (European patent), CA, CH (European patent), DE (European patent), DK (European patent), ES (European patent), FR (European patent), GB (European patent), GR (European patent), IT (European patent), JP, LU (European patent), MC (European patent), NL (European patent), NO, SE (European patent). Published <i>With international search report.</i> <i>Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.</i>

(54) Title: INTERMITTENT SIGNAL ACTUATED NEBULIZER SYNCHRONIZED WITH EXHALATION

**(57) Abstract**

A self-contained, high capacity nebulizer (10), having automatic mixing (28) and temperature control (34) features is provided. The nebulizer is designed for use in conjunction with mechanical respirators (70), ventilators, or breathing machines, and for this purpose will use electrical signals (8) generated by or received from the respirator (70) to automatically control and synchronize the nebulizing and mixing functions such that nebulization occurs only during the exhalation phase of the respiratory function to load the gas passageway of the respirator (70) to the patient with a standardized dose of medicinal aerosol. Upon commencement of the inhalation phase, the aerosol in the gas passageway is ventilated into the lungs of the patient to which it is attached.

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AT	Austria	FI	Finland	MI	Mali
AU	Australia	FR	France	MN	Mongolia
BB	Barbados	GA	Gabon	MR	Mauritania
BE	Belgium	GB	United Kingdom	MW	Malawi
BF	Burkina Faso	GN	Guinea	NL	Netherlands
BG	Bulgaria	GR	Greece	NO	Norway
BJ	Benin	HU	Hungary	PL	Poland
BR	Brazil	IE	Ireland	RO	Romania
CA	Canada	IT	Italy	RU	Russian Federation
CF	Central African Republic	JP	Japan	SD	Sudan
CG	Congo	KP	Democratic People's Republic of Korea	SE	Sweden
CH	Switzerland	KR	Republic of Korea	SN	Senegal
CI	Côte d'Ivoire	LI	Liechtenstein	SU	Soviet Union
CM	Cameroon	LK	Sri Lanka	TD	Chad
CS	Czechoslovakia	LU	Luxembourg	TG	Togo
DE	Germany	MC	Monaco	US	United States of America
DK	Denmark	MG	Madagascar		
ES	Spain				

-1-

INTERMITTENT SIGNAL ACTUATED NEBULIZER SYNCHRONIZED
WITH EXHALATION

This application is a continuation-in-part of
copen ding U.S. Patent Application Serial No.
5 07/585,616, filed on September 20, 1990, which is a
continuation of U.S. Patent Application Serial No.
270,520, filed on November 14, 1988, now abandoned,
which is a continuation of U.S. Patent Application
Serial No. 07/071,202, filed on July 8, 1987, now
10 U.S. Patent 4,832,012.

Technical Field

The present invention relates to nebulizers for
creating medicinal aerosols for inhalation therapy.
In particular, the present invention relates to
15 nebulizers used during the exhalation phase of the
breathing cycle in conjunction with and without
interfering with mechanical breathing machines which
are used to ventilate the lungs of patients who
cannot breathe unaided.

20 Background Art

The thin membrane of the lungs provides an
easily penetrated, convenient and generally safe
means for obtaining rapid absorption of medication by
the body. This is especially desirable where the
25 lungs themselves are diseased or injured. Such
medication or drugs are generally delivered to the
lung membrane in the form of a fine mist or aerosol
which is breathed into the lungs through the nose or
mouth of the patient. A variety of devices, called
30 nebulizers by those skilled in the art, have been
developed for converting liquids into fine aerosols

-2-

for this purpose. The simplest of these devices is the hand-held atomizer which converts a liquid to an aerosol when a bulb is compressed to produce a jet of air which atomizes the medication and propels it out of the atomizer. To be effective, the aerosols need to be provided at high concentrations and with droplet size in the respirable range (mass median aerodynamic diameter less than 3 micrometers).

Nebulizers are particularly useful for initiating and continuing respiratory therapy in conjunction with respirators, mechanical ventilators or breathing machines (hereinafter referred to generically as respirators) used to ventilate the lungs of patients having serious respiratory impairment. While some respirators incorporate nebulizers in their design, many do not. Nebulizers incorporated into the structure of such respirators often suffer from many disadvantages. One such disadvantage is severely limited capacity for medication to be nebulized, requiring frequent interruptions in the therapy as new medication is added to the nebulizer reservoir.

Most, if not all, such nebulizers are incorporated in respirators in which the inhalation and exhalation phases of the breathing cycle are triggered by changes in air pressure caused by the patient himself. Such "demand" respirators are not useful for patients whose respiratory systems are paralyzed and incapable of causing even slight changes in air pressure. These patients are aided by mechanical respirators in which the phases of the breathing cycle are triggered by electrical signals. There is now no effective means for patients on such respirators to receive aerosol treatment.

-3-

Thus, the need exists for a nebulizer which can be attached to a mechanical respirator, especially those in which the breathing cycle is controlled by an electrical signal, which has a reservoir capacity sufficient to enable several hours of continuous treatment, which can prevent the settling of suspensions or mixtures without creating nebulization-destroying turbulence.

U.S. Patent 4,832,012 discloses the principal of signal actuated synchronization of nebulization for delivery of aerosolized medicine to patients whose breathing is supported or augmented by a mechanical respiratory. In that reference, nebulization could be effected during inhalation or exhalation, but the primary trust of that reference was to provide aerosols during the inhalation phase of the breathing cycle to mix with the inhalation tidal volume provided by the respirator, and in synchrony with the normal operation of the respiratory. However, it has been found that the addition of volume of gas to mix with the inhalation tidal volume provided by the respirator, may interfere with the normal operation of the respirator in certain operating modes, and the medicinal aerosol is diluted by the portion of gas delivered by the respirator.

Summary of the Invention

The present invention is based upon the nebulization of medicine during and synchronized with the exhalation portion of each breath of the breathing cycle to fill the airline leading from the nebulizer to the patient with a standardized dose of medicinal aerosols that are delivered to the lung by the force of the flow of breathing gas (oxygen-enriched air) delivered by the respirator during the

-4-

inhalation portion of the breathing cycle. One advantage of this invention is that more concentrated standardized dose of aerosol is delivered to the patient with the first parcel of gas that enters the lungs for each breath during the inhalation process. In addition, the signal used to actuate the nebulizer may be obtained from the ventilator or from an independently generated signal established by the nebulization system utilizing the readily detected respiratory air line pressure or pressure drop across filter from exhaled gas flow. Also, certain safety monitoring features are incorporated into such a system to detect aerosol clogging of respiratory filters and prevent interference with the normal operation of the respirator.

The nebulization system of the present invention can be attached to or operated with a mechanical respirator utilizing either a breathing cycle electrical signal obtained from the respiratory or an independent electrical signal generated by the nebulizer system which detects and responds to the exhalation initiation of the respirator. Such a synchronized signal actuated nebulizer system is designed to operate during the exhalation phase of the breathing cycle while treating a sick patient and efficiently providing, in the short time available, a medicinal aerosol in the appropriate and desired volume, concentration, and particle size distribution for deposition in the respiratory airways of the lungs. An important feature of such a system is that all of the aerosol is generated quickly (in about 1 second or less) and in a way that does not interfere with the control system of the respirator. The nebulizer system has a reservoir of capacity sufficient to enable several hours of continuous

-5-

treatment and with provision to prevent the settling of suspensions or mixtures without creating nebulization-destroying turbulence, and provides a precisely measured volume of medicinal aerosol generated during patient exhalation in a manner to reach the patient at the precise moment when inhalation begins.

In one embodiment, the present invention provides a nebulizer for use with mechanical respirators which use electrical signals to control the breathing cycle. The nebulizer of this embodiment uses the existing electrical signals from the mechanical respirator to synchronize aerosol generation to fill the gas passageway from the respirator to the patient during the exhalation cycle. Upon the initiation of the inhalation cycle, the aerosol is delivered from the gas passageway to the patient. Nebulization is obtained in this embodiment using the premixed oxygen-enriched air provided at high pressure to the respirator. Automatic temperature regulation and stirring of the liquid medication is optionally provided to preclude concentration change, separation or settling of the medication. Finally, a large volume reservoir is provided to eliminate the need for refilling during lengthy treatment protocols.

Brief Description of the Drawings

Figure 1 is a schematic side view of a nebulizer of the present invention operationally attached to a mechanical respirator;

Figure 2 is a perspective view of the intermittent signal actuated system of the present invention.

-6-

Detailed Description of the Invention

Figure 1 shows a nebulizer apparatus 10 of the present invention operably connected to a mechanical respirator 70. The nebulizer apparatus 10 comprises, in a housing, compressed gas inlet 2, at one end of a compressed gas conduit 4, adapted to be connected to a compressed gas source at pressure indicated by gauge 5. Preferably this compressed gas source is the same source which is furnishing oxygen-enriched air to the respirator 70, and provides compressed air or oxygen mixture to the nebulizer ranging up to about 50 psig.

Compressed gas conduit 4 is connected at the other end to a first electrically operated nebulizer valve 7, and a plurality of second electrically operated nebulizer valves 6, all of which are substantially similar. Examples of such valves which have been found useful include the Honeywell Skinner K4M ultraminiature 4-way solenoid operated pneumatic valve and Numatics HS series 2-way solenoid operated valves. Three valves 6 are shown in Figure 1.

Nebulizer valves 6 and 7 are connected by a plurality of electrical lead wires 8 to a microprocessor 9 and are controlled by the microprocessor 9. The microprocessor 9 receives the signals from a signal source 72 on the respirator 70 which controls the inhalation/exhalation phase of the breathing cycle. The microprocessor 9 controls the valves 6 and 7 to provide for a safe and effective operation. Examples of signal source 72 include a respirator solenoid, such as a solenoid actuated inhalation valve, an external electronic monitoring system, or an electronic interface attached to a signal generator on respirator 70, such as an

-7-

interface connected to a logic circuit in the respirator.

A control unit 80, whose control panel is shown in Figure 2, is connected to the microprocessor 9. The control unit 80 controls the functions of the nebulizing apparatus 10 of the present invention.

Each of the nebulizer valves 6 connects the compressed gas source 4 to nebulizer conduits 12 leading to aerosol nozzles 22. Each nebulizer valve 6 switches between two positions as electrical on/off signals are received. In the first position, during the exhalation phase of the respirator 70 when the electric signal is "on", a passageway is opened between compressed gas conduit 4 and nebulizer conduits 12 and remain open until the desired aerosol volume has generated or until the inhalation phase is initiated by the respiratory 70 as controlled by microprocessor 9. In the second position, when the electric signal is "off", the nebulizer conduits 12 are sealed off.

Nebulizer conduits 12 are attached at their other ends to aerosol nozzles 22, which include liquid feed tubes 24 extending into reservoir 26. Reservoir 26 includes magnetic stirring bar 28 which is located in the bottom of the reservoir. The liquid medicine contained in reservoir 26 is preferably kept at constant temperature by a reservoir heater or cooler 34.

A chamber 14 houses an AC motor 11 which rotates a cooling fan 13 and a magnet 18. The rotation of the magnet 18 causes the stir bar 28 to rotate to prevent sedimentation or separation of medicinal constituents.

The liquid medicine in the reservoir 26 is drawn via the liquid feed tubes 24 and is converted by the

-8-

aerosol nozzles 22 into an aerosol having droplets with a mass median aerodynamic diameter less than about 3 micron. The aerosol is generated into the air space 25 above the reservoir 26. The aerosol generated in the air space 25 enters into an aerosol tube 31.

The temperature of the aerosol in the aerosol tube 31 is controlled by a temperature controller 33. In one embodiment, the temperature controller is simply an electric heater having a control unit. Within the aerosol tube 31 is also a neb-flow sensor 35. The neb-flow sensor 35 detects the amount of aerosol being delivered through the aerosol tube 31. The output of the neb-flow sensor 35 is supplied as a signal to the microprocessor 9 via neb-flow sensor pressure/vacuum lines 17.

The respirator 70 has an inhalation tube 71 and an exhalation tube 73. The inhalation tube 71 fluidically connects the respirator 70 to a patient and during the inhalation phase, breathing gas is supplied from the respirator 70 along the inhalation tube 71 into the respiratory tract of the patient. The aerosol tube 31 connects the air space 25 above the liquid 26 to the inhalation tube 71 at a nebulizer input 30. In addition, a pop-off valve 13 is also located in the inhalation tube 71. The function of the pop-off valve 13 is to relieve any pressure which is generated to dangerous levels within the inhalation tube 71. It functions purely as an emergency safety valve. Finally, an airway pressure sensor 15 is also positioned in the inhalation tube 71. The airway pressure sensor 15 generates a signal which is also supplied to the microprocessor 9 via airway pressure monitoring line 16. A humidifier 37 whose output is water vapor

-9-

mixed with the breathing gas is also connected to the inhalation tube 71.

The exhalation tube 73 fluidically connects the patient to the respirator 70. Located within the exhalation tube 73 is an exhalation filter 75. Upstream from the exhalation filter 75, i.e., between the exhalation filter 75 and the patient is an upstream filter pressure sensor 77. Downstream from the exhalation filter 75, i.e., between the exhalation filter 75 and the ventilator 70 is a downstream filter pressure sensor 79. The upstream filter pressure sensor 77 and the downstream filter pressure sensor 79 each provide a signal which is supplied to the microprocessor 9.

The solenoid 7 is also connected to receive gas from the gas conduit 4 and is adapted to supply gas to a decay flow line 11 to the exhalation tube 73, upstream from the upstream filter pressure sensor 77. Thus, the solenoid 7, when activated, provides a stream of compressed gas which is supplied into the exhalation tube 73, between the patient and the upstream filter pressure sensor 77. The function of the decay solenoid 7 is also controlled by the microprocessor 9.

The operation of the nebulizer apparatus 10 of the present invention will be understood as follows. The practitioner first determines the amount of volume per breath of the standardized dose of aerosol which is to be generated by the apparatus 10 of the present invention which is to be supplied to the inhalation tube 71. The amount is entered on the control unit 80. The microprocessor 9 receives the signal and based upon its knowledge of the gas pressure from the compressed gas conduit 4, and the cross-sectional area of each of nebulizing nozzles

-10-

22, the microprocessor 9 calculates the amount of time which the solenoids 6 would have to be activated in order to introduce the desired amount of aerosol into the inhalation tube 71. Alternatively, the signal from the neb-flow sensor 35 is used by the microprocessor 9 to turn off the nebulizer solenoids 6 when the desired charging volume has been generated.

When the mechanical respirator 70 begins the exhalation phase of the respiratory cycle, electrical signal 72 supplies the signal to the microprocessor 9. (As will be discussed hereinafter, a number of other signals are supplied to the microprocessor 9 to indicate the beginning of the exhalation cycle. These additional signals are used in the event the ventilator 70 cannot provide the electrical signal source 72 or is used as a safety backup to the electrical signal source 72.) When the mechanical respirator 70 begins the exhalation phase, the inhalation port 76 is closed. The exhalation port 74 is opened, opening the exhalation tube 73.

After the electrical signal source 72 generates the signal indicating the beginning of the exhalation phase, the microprocessor 9 activates the solenoids 6 to the three nebulizing nozzles 24. Thus, after the commencement of the exhalation phase, and after the detection of the electrical signal, maximum generation of the aerosol from the apparatus 10 commences and continues until the standardized volume or dose of aerosol has been generated. Compressed gas flows through the compressed gas conduit 4 into the three nebulizer conduits 12 and into the nozzles 22, which draw liquid via liquid feed tube 24 from the liquid reservoir 26. The aerosol is then generated and is supplied into the air space 25 above

-11-

the reservoir 26. The aerosol generated in the air space 25 then enters into the aerosol tube 31 where the temperature thereof is controlled by the temperature controller 33. The aerosol then leaves
5 the aerosol tube 31 and enters into the inhalation tube 71 through port 30. Generation of the standardized dose of aerosol fills the charging volume space 40 between the nebulizer input port 32 and the patient 41 in the inhalation tube 71. Any
10 excessive aerosol will enter the exhalation tube 73 and return to the respirator 70.

During the exhalation phase, the pressure in the inhalation tube 71 is monitored by the airway pressure sensor 15 and is supplied to the
15 microprocessor 9. This provides a safety signal to the microprocessor 9 to shut off the function of the aerosolization in the event pressure within the inhalation tube 71 builds to an excessive level or if inhalation begins. In addition, a mechanical safety
20 pop-off valve 13 is provided wherein in the event the pressure in the inhalation tube 71 exceeds the pressure regulation of the pop-off valve 13, the valve 13 would automatically open relieving the pressure in the inhalation tube 71.

During the exhalation cycle, the respirator 70 continuously monitors the pressure on the exhalation tube 73. In order to provide for a smooth decay flow of gas entering into the exhalation tube 73 from the patient, and thereby simulating smooth exhalation
30 reduction from the patient, the solenoid 7 is activated during the exhalation cycle. When the solenoid 7 is activated, the gas from the compressed gas conduit 4 fills a fixed volume chamber 82. The fixed volume chamber 82 has a calibrated orifice
35 which is connected to the decay flow line 11 and is

-12-

supplied to the exhalation tube 73. During the time period in which the aerosol is being generated, the fixed volume chamber 82 is filled with breathing gas to a predetermined pressure. At the end of the charging period, the compressed gas from the gas conduit 4 is turned off. The gas from the fixed volume chamber 82 is then allowed to flow in a decay manner into the exhalation tube through the orifice connecting the chamber 82 to the decay flow line 11. When the pressure in the fixed chamber 82 gradually reduces, the flow entering the decay flow line 11 simulates a natural first order decay.

Synchronous with the beginning of the exhalation cycle, the three nebulizing nozzles 22 are turned on simultaneously or one at a time to produce the desired charging volume during a portion of the exhalation period to allow the respirator 70 to maintain and/or support the patient's spontaneous breathing effort without interference from the charging flow.

When the respirator 70 begins the inhalation phase of the respiratory cycle, the electrical signal source 72 switches to an "off" position. In the "off" position, the respirator inhalation port 76 opens; the respirator exhalation port 74 is closed.

The solenoid valves 6 are controlled by microprocessor 9 when first, the desired standardized dose is reached (usually only takes a portion of the exhalation phase), or secondly when microprocessor 9 detects the electrical signal source 72 turn to an "off" position. In the first priority, the solenoids 6 can be turned off one at a time. In the second case, the solenoids 6 are turned off immediately to allow respirator 70 to begin the inhalation phase.

-13-

The gradual turning off of the plurality of solenoids 6 generates a gradual pressure reduction and flow shaping that prevents spurious triggering of the respiratory ventilator 70 caused by rapid flow changes. Because the aerosol generated by the apparatus 10 of the present invention fills the inhalation tube 71 between the nebulizer input 30 and the patient with the desired standardized volume or aerosol dose, when the ventilator 70 begins the inhalation phase and pushes the gas in the inhalation tube 71 into the respiratory tract of the patient, the aerosol in the charging volume space 40 would be the first gas pushed into the lungs of the patient. Thus, the medicine produced by the aerosol would be first delivered to the patient during the inhalation cycle.

The advantage of the apparatus 10 and method of the present invention is that generating the aerosol and introducing it into the charging volume space 40 during the exhalation phase means the aerosol is pre-charged in the inhalation tube. Further, the amount of aerosol in the charging volume space 40 can be metered or controlled by the microprocessor 9. In addition, the introduction of aerosol during the exhalation phase does not perturb the pressure of the gas from the respirator 70 delivered during the inhalation phase.

As previously discussed, the source of electrical signal 72 may not be provided by all ventilators 70. The upstream filter sensor 77 and the downstream filter sensor 79 each provides a signal via the exhalation filter sensor pressure/vacuum lines 19, the difference of which indicates the commencement of the exhalation phase. Thus, upon the immediate commencement of the

-14-

exhalation phase, a pressure differential would be detected between the upstream filter sensor 77 and the downstream filter sensor 79, respectively. This pressure differential, supplied as a signal to the microprocessor 9, would indicate to the microprocessor 9 that the exhalation cycle has commenced. This signal can be used by microprocessor 9 to begin nebulization when no respirator electrical signal is available. Alternatively, the airway pressure sensor 15 supplies a signal to the microprocessor 9 indicating the beginning of the exhalation and also the beginning of the inhalation for control of the nebulization by microprocessor 9 when no respirator electrical signal is available.

In addition, there are many safety considerations with the apparatus 10 of the present invention. With the upstream and downstream filter sensor 77 and 79 respectively having an exhalation filter 75 therebetween, the condition of the exhalation filter 75 can be continuously checked. As the apparatus 10 of the present invention is continuously used, and as the filter 75 becomes increasingly clogged, the pressure differential between the upstream filter sensor 77 and the downstream filter sensor 79 would increase. Alternatively, the loading/clogging of the exhalation filter can be detected using the airway pressure sensor 15 which supplies a signal to microprocessor 9 via line 16. This is because airway pressure during nebulization is a function of the resistance of the exhalation filter. The filter loading/clogging can be detected by the microprocessor 9 and can be signaled on the control unit 80 as an alarm that the exhalation filter 75 needs to be examined and/or changed.

-15-

As previously discussed, the airway pressure sensor 15 provides an independent airway pressure measurement upstream to exhalation filter to monitor the patients safety. Finally, the control unit 80

5 can control the apparatus 10 to cause it to pause its operation. This provides an independent check on the respirator system 70. The control unit shown in Figure 2 provides for setting of charging volume, respirator selection (for different commercial

10 respirators), heater temperature, nebulizer hold option, alarm test option, alarm reset, and alarm silence. Further, the control unit displays respirator selection, charging volume, alarm, warning, and caution, indication of exhalation filter

15 loading, patient peak inspiratory pressure, heater temperature and nozzle gas pressure. Signals from the neb-flow sensor 35 are used to alarm if either inadequate charging volume is generated or if the nebulizer nozzle 24 malfunction in the "on" position.

20 The microprocessor 9 provides yet additional safe and effective operation for the apparatus 10 of the present invention. In the preferred embodiment, the microprocessor 9 is an Intel 8751 available from Intel Corporation. A copy of the program, written in

25 the assembly language, for execution by the microprocessor 9 is attached as Exhibit A.

```

:VISANSA
$TITLE SAMPLE SIGNALS AND CONTROL VISAN 9
:SAMPLE VENTILATOR ANALOG SIGNAL AND
:PRESSURE AND FLOW SIGNALS FROM NEBULIZER
:AND CONTROL 3 NEBULIZER VALVES.
:CONTROL SERIAL INTERFACE WITH OPERATOR
:SWITCHES AND DISPLAYS.
:
000B = FLOTIM EQU 11 :TIME=2.2S
0032 = NOFLOTIM EQU 50 :TIME=10S
002D = FLO_TH EQU 45 :FLO 18LPM,0.14CMWC,0.17V,2DH
008C = NOFLO_TH EQU 140 :FLO 35LPM,1.12CMWC,0.5V,8CH
00E0 = PIP_THRESH SET 120*8/5+32 ;THR=4.4V,EOH,120CM
0037 = FILTAWP_THRESH EQU 55 :PRES=34CM,1.07V,37H
008D = FILTDP_THRESH EQU 141 :PRES=5.5CM,2.75V,8DH
0008 = PATINSP_THRESH SET 5*8/5 ;PEEP-AWP= 5 CM WC
00A0 = TEMP_HI SET 80*2 ;UPPER LIM 80C,AOH
:
0000 FSEG
:
:;BANK0
0001 = ALTNAME R1,RVENT_SIG ;VENTILATOR SIGNAL
0002 = ALTNAME R2,RFLT_FLO ;EXH FILT DP SIGNAL
0003 = ALTNAME R3,RAW_PRESS ;AWP TAP AT VENT
0004 = ALTNAME R4,RNEB_FLO ;NEB OUTPUT DP
0005 = ALTNAME R5,RTEMP ;TEMP DEG C * 2
0006 = ALTNAME R6,RVENT :VENTILATOR # SELECTED
:;BANK1
0001 = ALTNAME R1,RCHG_TIM ;NEB CHARGE TIME
0002 = ALTNAME R2,RDIV10 ;TIMER DIV BY 10
0003 = ALTNAME R3,RDIV5 ;TIMER DIV BY 5
0004 = ALTNAME R4,RON_TIM ;NEB FLOW ON TIME
0005 = ALTNAME R5,ROFF_TIM ;NEB FLOW OFF TIME
0006 = ALTNAME R6,RSIL_TIM ;AUDIO OFF TIME
0007 = ALTNAME R7,RHOLD_TIM ;NEB OFF TIME
0000 ENDS
:
0000 DSEG
0023 = LED1 DATA 23H :LED BANKS
0026 = LED2 DATA 26H
0025 = LED3 DATA 25H
0028 = CHG_VOL DATA 28H ;HUNS DEC DISPLAY
0029 = DEC_HUN DATA 29H :NUMBER FOR DISPLAY
002A = DEC_TEN DATA 2AH
002B = DEC_ONE DATA 2BH
002C = FLTLD_HUN DATA 2CH ;FILTER LOAD SETTING
002D = FLTLD_TEN DATA 2DH : 25%, 50% OR 75%
002E = FLTLD_ONE DATA 2EH
002F = THREE_CYCLE DATA 2FH :THREE BREATH COUNTS
0040 = FLTFLD_LO DATA 40H ;RUNNING AVG CALC
0044 = FLTFLD_AVG DATA 44H
0045 = CLOG_LO DATA 45H
0046 = CLOG_HI DATA 46H
0048 = AWP_LO DATA 48H
004C = AWP_AVG DATA 4CH
004D = AWP_MAX DATA 4DH

```

EXHIBIT A

-17-

```

004E = PIP_STORE DATA 4EH
0050 = POSSUM DATA 50H ;NEB POS SUM
0051 = NEGSUM DATA 51H ;NEB NEG SUM
0055 = FLTLD25 DATA 55H ;PERCENT FILTER LOAD
0056 = FLTLD50 DATA 56H
0057 = FLTLD75 DATA 57H
0058 = PIP_LO DATA 58H
005B = PIP_AVG DATA 5BH
0060 = PEEP_LO DATA 60H
0063 = PEEP_AVG DATA 63H
0011 = TEMP_SET DATA 11H
0012 = TEMP_DEC DATA 12H
0014 = ONTIMER DATA 14H
0015 = OFFTIMER DATA 15H
0019 = SET_CHGTIM DATA 19H ;CONTROLS CHARGE VOL
001A = VENT_LO DATA 1AH ;LOWER THRESH
001B = VENT_HI DATA 1BH ;UPPER THRESH
001C = TEMP_STORE DATA 1CH ;TEMPORARY STORE
001D = DIVIDE1 DATA 1DH ;TRANS_DEL
001E = DIVIDE2 DATA 1EH
0068 = VENT_LOW DATA 68H
006C = VENT_AVG DATA 6CH
0028 = ENDS
;
0000 = BSEG
0000 = WAIT BIT 0H ;FIVE BREATH WAIT
0001 = EXH BIT 1H ;EXHALATION PERIOD
0002 = DIV21 BIT 2H ;TIMER
0003 = VOL_CHG BIT 3H ;OP CHANGING VOL SET
0004 = VEN_SEL BIT 4H ;OP SELECTING VENTILATOR
0014 = BEEP BIT 14H ;AUDIO ON/OFF
0006 = SIL BIT 6H ;TWO MIN SILENCE
0007 = SPON_BR BIT 7H ;PATIENT BREATH
0008 = HOLD BIT 8H ;NEB OFF
0009 = SEE_PIP BIT 09H ;DISPLAY PIP
000B = DIV22 BIT 0BH ;TIMER
000C = ALM BIT 0CH ;AUDIO ALM SET
000D = OFF_ALM BIT 0DH ;BLINK_BEEP
000A = ALM_TST BIT 0AH ;SET DURING TEST
000E = DIV24 BIT 0EH ;START DELAY
000F = FLOW BIT 0FH ;NEB FLOW ON
0010 = SEE_TEMP BIT 10H
0011 = SEE_LD BIT 11H
0012 = DEL1 BIT 12H
0013 = DEL_4TENTHS BIT 13H ;TIMER
0015 = INSP BIT 15H ;INSP TIME
0016 = CLOG1 BIT 16H ;COUNT FLT LD SAMP
0017 = CLOG2 BIT 17H
001C = L14 BIT 1CH ;LD BAT LED1
001D = L15 BIT 1DH ;FILTER CHANGE
001E = L16 BIT 1EH ;WAIT 5 CYCLES
001F = L17 BIT 1FH ;LD FLOW
0034 = L24 BIT 34H ;NO FLOW LED2
0035 = L25 BIT 35H ;NEB HOLD
0036 = L26 BIT 36H ;FILT CLOG

```

```

0037 =      L27 BIT 37H :CONT FLOW
002C =      L34 BIT 2CH :HI PRESS          LED3
0020 =      L35 BIT 20H :HI TEMP
0038 =      DIV23 BIT 38H :TIMER
0039 =      CLK BIT 39H      ;TIMER 0.2S
003A =      HEAT BIT 3AH      ;HEATER ON
003B =      TEMP BIT 3BH
0025 =      ENDS
;
0000 =      CSEG
; MACRO DEFINITIONS
;
ANALOG MACRO SAVE      :ANALOG-DIGITAL CONVERSION
NOP      ;DELAY TIME FOR MUX
NOP
NOP
NOP
NOP
CLR P2.3      ;START CONVERSION
NOP      ;ALLOW CONV. TIME 5 MICROSEC
NOP
NOP
MOV SAVE,P1      ;SAVE DIGITAL OUTPUT
SETB P2.3
ENDM
;
;
RUNNING_AVG MACRO LODATA,N,INSIG,AVG
;CALCULATES RUNNING AVERAGE OF N BYTES IN DATA MEMORY
;WITH A LOW ADDRESS OF LODATA. INPUT SIGNAL IS LOCATED
;AT INSIG. AVERAGE OUTPUT IS AT AVG.
PUSH PSW
PUSH ACC
PUSH B
CLR PSW.3      ;BANK0
CLR PSW.4
MOV A,#LODATA      ;SET RO
ADD A,#N
DEC A
MOV RO,A
NEXT1:
DEC RO
MOV A,@RO      ;SHIFT UP
INC RO
MOV @RO,A
DEC RO
CJNE RO,#LODATA,NEXT1 :LODATA ADDRESS
MOV A,INSIG      ;MOV NEW DATA TO LODATA
MOV B,#N
DIV AB
MOV @RO,A
MOV A,#LODATA :ADD TO CALC AVG
ADD A,#N
DEC A
MOV TEMP_STORE,A

```

```
MOV A,@RO
XCH A,RO
NEXT2:
XCH A,RO
INC RO
ADD A,@RO
XCH A,RO
CJNE A,TEMP_STORE,NEXT2
XCH A,RO
MOV AVG,A
POP B
POP ACC
POP PSW
ENDM
```

```
FIFO MACRO NEW_IN,N1,NEW_DATA
;REGISTER STORES SUCCESSIVE DATA FIFO
;FROM NEW_DATA SOURCE INTO REGISTER ADDRESS
;NEW_IN. N1 IS THE NUMBER OF DATA STORED.
CLR PSW.3      ;BANK0
CLR PSW.4
MOV A,#NEW_IN  ;SET RO
ADD A,#N1
DEC A
MOV RO,A
NEXT3:
DEC RO
MOV A,@RO      ;SHIFT UP
INC RO
MOV @RO,A
DEC RO
CJNE RO,#NEW_IN,NEXT3  ;NEW_IN ADDR
MOV NEW_IN,NEW_DATA
ENDM

BINARY_BCD MACRO HUN,TEN,ONE
;CONVERTS BYTE LOCATED IN ACC TO DECIMAL
;AND STORES RESULT IN HUN, TEN AND ONE.
MOV HUN,#0      ;CLEAR REGISTERS
MOV TEN,#0
MOV ONE,#0
CALC_HUN:      ;;SUBTRACT 100
MOV B,A
NEXTSUB1:
CLR C
SUBB A,#100
JC CALC_TEN
INC HUN
MOV B,A        ;SAVE
SJMP NEXTSUB1
CALC_TEN:      ;;SUBTRACT 10
MOV A,B
NEXTSUB2:
CLR C
SUBB A,#10
JC CALC_ONE
```

-20-

```

INC TEN
MOV B,A
SJMP NEXTSUB2
CALC_ONE:
MOV ONE,B
MOV A,HUN
JNZ BCD_OUT
MOV HUN,#0FH ;BLANK
MOV A,TEN
JNZ BCD_OUT
MOV TEN,#0FH ;BLANK
BCD_OUT:
ENDM
:
:
1000 ORG 1000H
; %S
BEGIN:
1000 0130 AJMP INITIALIZE
1003 ORG 1003H ;MANUAL SWITCH INT..INT0
1003 0219CC LJMP MAN_SW
100B ORG 100BH ;TIMER 0 INT..TFO
100B 61F3 AJMP TIM_SAMP
1013 ORG 1013H ;LOW BATTERY INT.,INT1
1013 C28B CLR IE1
1015 D21C SETB L14
1017 852399 MOV SBUF,LED1
101A D125 ACALL TRANS_DEL
101C 32 RETI
;
1030 ORG 1030H
INITIALIZE: ;:SET REGISTERS
1030 D212 SETB DEL1
INIT1:
1032 538700 ANL PCON,#00H ; SMOD = 0
1035 758920 MOV TMOD,#00100000B ; TIME 1 MODE 2, TIME 0 MODE 0
1038 759850 MOV SCON,#01010000B ; SERIAL PORT MODE 1
103B 758C70 MOV TH0,#70H ;SET TIMER
103E 758DFD MOV TH1,#0FDH ; BAUD RATE 9600
1041 75A078 MOV P2,#78H ; OUTPUTS OFF
1044 75A887 MOV IE,#87H ;ENABLE EX1,ETO,EXO
1047 75B802 MOV IP,#02H ;FIRST PRIORITY TIMER 0
104A 758850 MOV TCON,#50H ;TIMERS ACTIVE, IT1 & ITO
;LOW LEVEL TRIGGER

104D 758000 MOV P0,#00H
1050 758130 MOV SP,#30H ; STACK ADDRESS
1053 752000 MOV 20H,#00H ;CLEAR BITS
1056 752100 MOV 21H,#00H
1059 752200 MOV 22H,#00H
105C 752700 MOV 27H,#00H
105F D2D3 SETB PSW.3 ;BANK1
1061 7BC5 MOV RDIV5,#5 ;R3
1063 7A0A MOV RDIV10,#10 ;R2
1065 7E78 MOV RSIL_TIM,#120 ;R6,DEL 2 MIN (3CH)
1067 7F78 MOV RHOLD_TIM,#120 ;R7

```

```

1069 7D32      MOV ROFF_TIM,#NOFLOTIM ;R5. CLEAR REGISTER
106B 7C0B      MOV RON_TIM,#FLOTIM ;R4
106D 7900      MOV RCHG_TIM,#0 ;R1
106F 751532    MOV OFFTIMER,#NOFLOTIM
1072 75140B    MOV ONTIMER,#FLOTIM
1075 755000    MOV POSSUM,#0
1078 755100    MOV NEGSUM,#0
107B 751128    MOV TEMP_SET,#40 :DEFAULT
107E 752C00    MOV FLTLD_HUN,#00H
1081 752D01    MOV FLTLD_TEN,#01H
1084 752E02    MOV FLTLD_ONE,#02H
1087 751DFF    MOV DIVIDE1,#0FFH ;TRANS DEL
108A 751E04    MOV DIVIDE2,#04H
108D D202      SETB DIV21 ;TIMER
108F D20B      SETB DIV22
1091 751B45    MOV VENT_HI,#45H ;THRESH = 2.7V/2 = 1.35V
1094 751A3B    MOV VENT_LO,#3BH ;THRESH = 2.3V/2 = 1.15V
1097 75192B    MOV SET_CHGTIM,#40 ;CASEB GIVES 60
109A C2D3      CLR PSW.3 ;BANK0
109C 7E13      MOV RVENT,#13H ;R6,VENT #
109E 8E99      MOV SBUF,RVENT
10A0 D125      ACALL TRANS_DEL
10A2 752344    MOV LED1,#44H ;WAIT LED ON
10A5 852399    MOV SBUF,LED1
10A8 D125      ACALL TRANS_DEL
10AA 752605    MOV LED2,#05H
10AD 852699    MOV SBUF,LED2
10B0 D125      ACALL TRANS_DEL
10B2 752506    MOV LED3,#06H
10B5 852599    MOV SBUF,LED3
10B8 D125      ACALL TRANS_DEL
10BA 752B40    MOV CHG_VOL,#40H ;CASEB GIVES 600ML
10BD 301212    JNB DEL1,CONT5
10C0 C212      CLR DEL1
10C2 C20B      CLR DIV22
10C4 C20E      CLR DIV24
10C6 200E02    DELAY1: JB DIV24,DELAY2
10C9 80FB      SJMP DELAY1
10CB 300E02    DELAY2: JNB DIV24,END_DEL
10CE 80FB      SJMP DELAY2
10D0 0132      END_DEL: AJMP INIT1
10D2 121765    CONT5: LCALL CASEB1
10D5 00        NOP
10D6 00        NOP
10D7 00        NOP
;
10DB 12156E    MAIN_LOOP: ::INSP/EXP CYCLE
10DB 200C51    LCALL SERVICE
10DE C2D3      JB ALM,ALARM
10E0 C2D4      CLR PSW.3 :BANK0
10E2 E51B      CLR PSW.4
10E4 C3        MOV A,VENT_HI ;WAIT FOR SOI
10E5 956C      CLR C
10E7 50EF      SUBB A,VENT_AVG :R1
10E7 50EF      JNC MAIN_LOOP ;?NOT INSP

```

-22-

```

10E9 D215      SETB INSP

                  EOI:  ;;WAIT FOR EOI
10EB 12156E    LCALL SERVICE
10EE 200C3E    JB ALM.ALARM
10F1 E51A      MOV A,VENT_LO
10F3 C3        CLR C
10F4 956C      SUBB A,VENT_AVG ;R1
10F6 40F3      JC EOI      ;?NOT EOI
10FB C215      CLR INSP

10FA D2D3      SETB PSW.3  ;BANK1
10FC C2D4      CLR PSW.4
10FE 7900      MOV RCHG_TIM,#00H ;R1
                  CHK_EXH:  ;;FIND AWP PEAK & DROP
1100 E54D      MOV A,AWP_MAX
1102 C3        CLR C
1103 954C      SUBB A,AWP_AVG
1105 401B      JC DELAYS    ;?AWP MAX > AWP AVG
                  CHK_AWP:  ;;CHK AWP DROP
1107 F5F0      MOV B,A      ;SAVE
1109 E54D      MOV A,AWP_MAX
110B C3        CLR C
110C 9563      SUBB A,PEEP_AVG ;AWP MAX - PEEP
110E 4007      JC SET_EXH   ;AWP<PEEP
1110 84        DIV AB
1111 9405      SUBB A,#5
1113 4002      JC SET_EXH   ;?DROP 20%
1115 2122      AJMP DELAYS5
1117 D201      SET_EXH:  SETB EXH
1119 854D4E    MOV PIP_STORE,AWP_MAX ;NEW PIP
111C 754D00    MOV AWP_MAX,#0  ;RESET
111F 2150      AJMP CHK_PEAK

1121 00        NOP
                  DELAYS:  ;;WAIT 0.5S
1122 D2D3      SETB PSW.3  ;BANK1
1124 C2D4      CLR PSW.4
1126 7432      MOV A,#50
1128 C3        CLR C
1129 99        SUBB A,RCHG_TIM
112A 50D4      JNC CHK_EXH  ;?NOT 0.5S
112C 00        NOP
112D 00        NOP
112E 00        NOP

                  ALARM:
112F D20C      SETB ALM
1131 43A070    ORL P2,#01110000B ;OFF VALVES
1134 200605    CHK_SIL:  JB SIL.CONT
1137 200802    JB HOLD.CONT
113A D2A7      SETB P2.7 ;BUZZER ON
113C D200      CONT:  SETB WAIT
113E D21E      SETB L16   ;WAIT
1140 852399    MOV SBUF,LED1

```



```

1143 D125      ACALL TRANS_DEL
1145 12156E    LCALL SERVICE
1148 200CE9    JB ALM.CHK_SIL
114B 752F00    MOV THREE_CYCLE,#0
114E 01D8      AJMP MAIN_LOOP

CHK_PEAK:      ::PRESS LIMIT 120 CM
1150 20000A    JB WAIT,CALC_PIP
1153 E54E      MOV A,PIP_STORE
1155 C3        CLR C
1156 9563      SUBB A,PEEP_AVG
1158 C3        CLR C
1159 94E0      SUBB A,#PIP_THRESH
115B 5046      JNC HIPRESS
CALC_PIP:
115D          RUNNING_AVG PIP_LO,3,PIP_STORE,PIP_AVG
+             ;CALCULATES RUNNING AVERAGE OF 3 BYTES IN DATA MEMORY
+             ;WITH A LOW ADDRESS OF L0DATA. INPUT SIGNAL IS LOCATED
+             ;AT INSIG. AVERAGE OUTPUT IS AT AVG.
+115D C0D0      PUSH PSW
+115F C0E0      PUSH ACC
+1161 C0F0      PUSH B
+1163 C2D3      CLR PSW.3 :BANK0
+1165 C2D4      CLR PSW.4
+1167 7458      MOV A,#PIP_LO :SET RO
+1169 2403      ADD A,#3
+116B 14        DEC A
+116C FB        MOV RO,A
+             NEXT10001:
+116D 18        DEC RO
+116E E6        MOV A,@RO :SHIFT UP
+116F 08        INC RO
+1170 F6        MOV @RO,A
+1171 18        DEC RO
+1172 B858FB    CJNE RO,#PIP_LO,NEXT10001 :L0DATA ADDRESS
+1175 E54E      MOV A,PIP_STORE :MOV NEW DATA TO PIP_LO
+1177 75F003    MOV B,#3
+117A 84        DIV AB
+117B F6        MOV @RO,A
+117C 7458      MOV A,#PIP_LO ;ADD TO CALC PIP_AVG
+117E 2403      ADD A,#3
+1180 14        DEC A
+1181 F51C      MOV TEMP_STORE,A
+1183 E6        MOV A,@RO
+1184 CB        XCH A,RO
+             NEXT20001:
+1185 CB        XCH A,RO
+1186 08        INC RO
+1187 26        ADD A,@RO
+1188 CB        XCH A,RO
+1189 B51CF9    CJNE A,TEMP_STORE,NEXT20001
+118C CB        XCH A,RO
+118D F55B      MOV PIP_AVG,A
+118F D0F0      POP B
+1191 D0E0      POP ACC

```

```

+1193 D0D0      POP PSW
1195 00         NOP
1196 00         NOP
1197 00         NOP
1198 200013     JB WAIT,STRT_EXH
1198 200810     JB HOLD,STRT_EXH
119E 53A08F     ANL P2,#10001111B ;ON VALVES
11A1 21AE      AJMP STRT_EXH
                HIPRESS:
11A3 D22C      SETB L34 ;HI PRESS
11A5 852599     MOV SBUF,LED3
11A8 D125      ACALL TRANS_DEL
11AA 00        NOP
11AB 212F      ALARM1: AJMP ALARM
11AD 00        NOP

                STRT_EXH:
11AE D2D3      SETB PSW.3 ;BANK1
11B0 C2D4      CLR PSW.4
11B2 7900      MOV RCHG_TIM,#00H ;R1,RST CHARGE TIME

                CHARGE:
11B4 C2D3      CLR PSW.3 ;BANK 0
11B6 12156E     LCALL SERVICE
11B9 200CEF     JB ALM.ALARM1
11BC E51B      MOV A,VENT_HI ;VENTILATOR INSPIRATION?
11BE C3        CLR C
11BF 956C      SUBB A,VENT_AVG
11C1 5023      JNC CHK_CHGTIM ;?NO VENT INSP1
11C3 43A070     ORL P2,#01110000B ;OFF VALVES

                CHK_VOL: SETB PSW.3 ;BANK1
11C6 D2D3      CLR PSW.4
11C8 C2D4      JB WAIT,CHK_WAIT1
11CA 200016     MOV A,SET_CHGTIM
11CD E519      CLR C
11CF C3        SUBB A,RCHG_TIM ;R1
11D0 99        JC CHK_WAIT1 ;:VOL>SET
11D1 4010      MOV B,A
11D3 F5F0      MOV A,SET_CHGTIM
11D5 E519      DIV AB
11D7 84        SUBB A,#10
11D8 940A      JNC CHK_WAIT1
11DA 5007      SETB L17 ;LO FLOW LED
11DC D21F      MOV SBUF,LED1
11DE 852399     ACALL TRANS_DEL
11E1 D125      CHK_WAIT1: AJMP CHK_WAIT
11E3 6108      NOP
11E5 00        CHK_CHGTIM:
11E6 E519      MOV A,SET_CHGTIM ;SET VOLUME REACHED?
11E8 D2D3      SETB PSW.3 ;BANK1
11EA C3        CLR C
11EB 99        SUBB A,RCHG_TIM ;R1
11EC 50C6      JNC CHARGE ;?VOL < SET VOL
11EE 43A070     ORL P2,#01110000B ;OFF VALVES

```

-25-

```

11F1 20004B      JB WAIT,CHK_EOEXH1

11F4 101629      JBC CLOG1,FIRST_SAMP :MEAS FLT LD SAMP
11F7 30172B      JNB CLOG2,FLT_LD
11FA C217        CLR CLOG2 :SECOND SAMPLE
11FC E544        MOV A,FLTFLO_AVG
11FE 2545        ADD A,CLOG_LO
1200 F546        MOV CLOG_HI,A ;UPPER LIM FILT CLOG
1202 C3          CLR C
1203 13          RRC A ;DIV BY 2
1204 F545        MOV CLOG_LO,A :LOWER LIM FILT CLOG
1206 C3          CLR C
1207 13          RRC A ;HALF CLOG LO
1208 F5F0        MOV B,A ;SAVE
120A 2545        ADD A,CLOG_LO
120C F556        MOV FLTLD50.A ;STORE 50% LEVEL
120E E5F0        MOV A,B
1210 C3          CLR C
1211 13          RRC A ;ONE FOURTH CLOG LO
1212 F5F0        MOV B,A ;SAVE
1214 2545        ADD A,CLOG_LO
1216 F555        MOV FLTLD25.A ;STORE 25% LEVEL
1218 E5F0        MOV A,B
121A 2556        ADD A,FLTLD50
121C F557        MOV FLTLD75.A ;STORE 75% LEVEL
121E 4142        AJMP CHK_DPTHRESH

1220 854445      FIRST_SAMP: ;:FIRST FLT LD SAMP
1223 4142        MOV CLOG_LO,FLTFLO_AVG ;SAVE
                  AJMP CHK_DPTHRESH

1225 E544        FLT_LD: ;:SAVE FILT LOAD %
1227 C3          MOV A,FLTFLO_AVG
1228 9546        CLR C
122A 402F        SUBB A,CLOG_HI
122C D236        JC TEST75
122E 852399      SETB L26 ;FILTER CLOG LED
1231 D125        MOV SBUF,LED1
1233 752C10      ACALL TRANS_DEL
1236 752D01      MOV FLTLD_HUN,#10H ;SET FILTER LOAD 100%
1239 752E02      MOV FLTLD_TEN,#01H
123C 212F        MOV FLTLD_ONE,#02H
                  AJMP ALARM

123E 00          NOP
123F 41A7        CHK_EOEXH1: AJMP CHK_EOEXH
1241 00          NOP

1242 E544        CHK_DPTHRESH:
1244 C3          MOV A,FLTFLO_AVG
1245 948D        CLR C
1247 40F6        SUBB A,#FILTDP_THRESH
1249 D236        JC CHK_EOEXH1 ;BELOW THRESH
124B 852699      SETB L26 ;FILT CLOG LED
124D 852699      MOV SBUF,LED2

```

```
124E D125      ACALL TRANS_DEL
1250 752C10     MOV FLTLD_HUN,#10H
1253 752D01     MOV FLTLD_TEN,#01H
1256 752E02     MOV FLTLD_ONE,#02H
1259 212F      AJMP ALARM

TEST75:        ;:TEST 75% CLOG
125B E544      MOV A,FLTFLD_AVG
125D C3        CLR C
125E 9557      SUBB A,FLTLD75
1260 4012      JC TEST50
1262 D21D      SETB L15 ;FILTER CHANGE LED
1264 852399     MOV SBUF,LED1
1267 D125      ACALL TRANS_DEL
1269 752CF0     MOV FLTLD_HUN,#0F0H ;BLANK
126C 752D71     MOV FLTLD_TEN,#71H
126F 752E52     MOV FLTLD_ONE,#52H
1272 4142      AJMP CHK_DPTHRESH
TEST50:        ;:TEST 50% CLOG
1274 E544      MOV A,FLTFLD_AVG
1276 C3        CLR C
1277 9556      SUBB A,FLTLD50
1279 400B      JC TEST25
127B 752CF0     MOV FLTLD_HUN,#0F0H
127E 752D51     MOV FLTLD_TEN,#51H
1281 752E02     MOV FLTLD_ONE,#02H
1284 4142      AJMP CHK_DPTHRESH
TEST25:        ;:TEST 25% CLOG
1286 E544      MOV A,FLTFLD_AVG
1288 C3        CLR C
1289 9555      SUBB A,FLTLD25
128B 400B      JC TEST0
128D 752CF0     MOV FLTLD_HUN,#0F0H
1290 752D21     MOV FLTLD_TEN,#21H
1293 752E52     MOV FLTLD_ONE,#52H
1296 4142      AJMP CHK_DPTHRESH
TEST0:
1298 752CF0     MOV FLTLD_HUN,#0F0H
129B 752DF1     MOV FLTLD_TEN,#0F1H
129E 752E02     MOV FLTLD_ONE,#02H
12A1 4142      AJMP CHK_DPTHRESH
12A3 00        NOP

12A4 212F      ALARM2: AJMP ALARM
12A6 00        NOP
CHK_EDEXH:
12A7 12156E     LCALL SERVICE
12AA 200CF7     JB ALM,ALARM2
12AD C2D3      CLR PSW.3 ;BANK0
12AF C2D4      CLR PSW.4
12B1 E51B      MOV A,VENT_HI
12B3 956C      SUBB A,VENT_AVG ;R1
12B5 503F      JNC PAT_INSP
12B7 C201      CLR EXH ;END OF EXHALATION
12B9           RUNNING_AVG PEEP_LO.3.AWP_AVG.PEEP_AVG
```

-27-

```

+          :CALCULATES RUNNING AVERAGE OF 3 BYTES IN DATA MEMORY
+          ;WITH A LOW ADDRESS OF LDATA. INPUT SIGNAL IS LOCATED
+          ;AT INSIG. AVERAGE OUTPUT IS AT AVG.
+12B9 C0D0  PUSH PSW
+12BB C0E0  PUSH ACC
+12BD C0F0  PUSH B
+12BF C2D3  CLR PSW.3 ;BANK0
+12C1 C2D4  CLR PSW.4
+12C3 7460  MOV A,#PEEP_LO ;SET RO
+12C5 2403  ADD A,#3
+12C7 14    DEC A
+12C8 F8    MOV RO,A
+          NEXT10002:
+12C9 18    DEC RO
+12CA E6    MOV A,@RO ;SHIFT UP
+12CB 08    INC RO
+12CC F6    MOV @RO,A
+12CD 18    DEC RO
+12CE 8B60F8 CJNE RO,#PEEP_LO,NEXT10002 ;LDATA ADDRESS
+12D1 E54C  MOV A,AWP_AVG ;MOV NEW DATA TO PEEP_LO
+12D3 75F003 MOV B,#3
+12D6 84    DIV AB
+12D7 F6    MOV @RO,A
+12DB 7460  MOV A,#PEEP_LO ;ADD TO CALC PEEP_AVG
+12DA 2403  ADD A,#3
+12DC 14    DEC A
+12DD F51C  MOV TEMP_STORE,A
+12DF E6    MOV A,@RO
+12E0 C8    XCH A,RO
+          NEXT20002:
+12E1 C8    XCH A,RO
+12E2 08    INC RO
+12E3 26    ADD A,@RO
+12E4 C8    XCH A,RO
+12E5 B51CF9 CJNE A,TEMP_STORE,NEXT20002
+12E8 C8    XCH A,RO
+12E9 F563  MOV PEEP_AVG,A
+12EB D0F0  POP B
+12ED D0E0  POP ACC
+12EF D0D0  POP PSW
12F1 00    NOP
12F2 00    NOP
12F3 00    NOP
12F4 6108  AJMP CHK_WAIT

          PAT_INSP:
12F6 E563  MOV A,PEEP_AVG
12F8 C3    CLR C
12F9 954C  SUBB A,AWP_AVG ;PEEP - AWP
12FB 40AA  JC CHK_EDEXH ;AWP > PEEP
12FD 9408  SUBB A,#PATINSP_THRESH
12FF 40A6  JC CHK_EDEXH ;?NO PAT INSP
1301 C201  CLR EXH
1303 D207  SETB SPON_BR

```

```

1305 00      NOP
1306 00      NOP
1307 00      NOP

CHK_WAIT:   ::CHECK 3 CYC WAIT
1308 30002E  JNB WAIT.GO_ON
1308 20042B  JB VEN_SEL.GO_ON
130E 200328  JB VOL_CHG.GO_ON
1311 200825  JB HOLD.GO_ON
1314 7402    MOV A.#2
1316 C3      CLR C
1317 952F    SUBB A,THREE_CYCLE
1319 501B    JNC INC3
131B C200    CLR WAIT
131D C21E    CLR L16
131F D216    SETB CLOG1
1321 D217    SETB CLOG2
1323 852399  MOV SBUF,LED1
1326 D125    ACALL TRANS_DEL
1328 7C00    MOV RON_TIM,#0 :RESET AFTER WAIT
132A 7D00    MOV ROFF_TIM,#0
132C 755000  MOV POSSUM,#0
132F 755100  MOV NEGSUM,#0
1332 6139    AJMP GO_ON
1334 00      NOP
1335 00      NOP

INC3:
1336 052F    INC THREE_CYCLE
1338 00      NOP
GO_ON:      ::START MAIN LOOP
1339 01D8    AJMP MAIN_LOOP
133B 00      NOP

OUT1: AJMP OUT
133C 61EB    OUT1: AJMP OUT
133E 00      NOP

BLINK_BEEP: ::ON/OFF DISPLAY & BUZZER
133F 1038FA  JBC DIV23.OUT1 :PERIOD 0.4S
1342 D238    SETB DIV23
1344 200AF5  JB ALM_TST,OUT1
1347 C2D3    CLR PSW.3 :BANK0
1349 C2D4    CLR PSW.4
134B 100D50  JBC OFF_ALM,TURN_OFF
TURN_ON:    ::DISPLAY/ALM ON
134E D20D    SETB OFF_ALM
1350 301F05  JNB L17,CHK_LED21
1353 852399  MOV SBUF,LED1 :RESTORE LED'S
1356 D125    ACALL TRANS_DEL
CHK_LED21:
1358 E526    MOV A.LED2
135A 54F0    ANL A.#0F0H
135C 6005    JZ CHK_LED31
135E 852699  MOV SBUF,LED2
1361 D125    ACALL TRANS_DEL

```

```

1363 E525      CHK_LED31:
1365 54F0      MOV A,LED3
1367 6005      ANL A,#0F0H
1369 852599    JZ CHK_VOL1
136C D125      MOV SBUF,LED3
136E 30030F    ACALL TRANS_DEL
1371 852899    CHK_VOL1: JNB VOL_CHG.TST_VENTSEL1
1374 D125      MOV SBUF.CHG_VOL ;SET HUNS
1376 759901    ACALL TRANS_DEL
1379 D125      MOV SBUF,#01H ;SET TENS TO 0
137B 759902    ACALL TRANS_DEL
137E D125      MOV SBUF,#02H ;SET ONES TO 0
1380 300404    ACALL TRANS_DEL
1383 8E99      TST_VENTSEL1:
1385 D125      JNB VEN_SEL,TST_TEMP1
1387 303B0A    MOV SBUF,RVENT
138A 851299    ACALL TRANS_DEL
138D D125      TST_TEMP1:
138F 759902    JNB TEMP,TST_BEEP1
1392 D125      MOV SBUF,TEMP_DEC ;TENS
1394 301454    ACALL TRANS_DEL
1397 200651    MOV SBUF,#02H ;ONES
139A D2A7      ACALL TRANS_DEL
139C 61EB      TST_BEEP1:
139E 301F08    JNB BEEP,OUT
13A1 E523      JB SIL,OUT
13A3 547F      SETB P2.7 ;BUZZER ON
13A5 F599      AJMP OUT
13A7 D125      TURN_OFF: ;:DISPLAY/ALM OFF
13A9 E526      JNB L17,CHK_LED22
13AB 54F0      MOV A,LED1
13AD 6005      ANL A,#7FH ;MASK LED'S
13AF 759905    MOV SBUF,A
13B2 D125      ACALL TRANS_DEL
13B4 E525      CHK_LED22:
13B6 54F0      MOV A,LED2
13B8 6005      ANL A,#0F0H
13BA 759906    JZ CHK_LED32
13BD D125      MOV SBUF,#05H
13BF 30030F    ACALL TRANS_DEL
13C2 7599F0    CHK_LED32:
13C5 D125      MOV A,LED3
13C7 7599F1    ANL A,#0F0H
13CA D125      JZ CHK_VOL2
13CC 7599F2    MOV SBUF,#06H
13CF D125      ACALL TRANS_DEL
13D1 300405    CHK_VOL2: JNB VOL_CHG.TST_VENTSEL2
13D3 7599F0    MOV SBUF,#0F0H ;OFF HUNS
13D5 D125      ACALL TRANS_DEL
13D7 7599F1    MOV SBUF,#0F1H ;OFF TENS
13DA D125      ACALL TRANS_DEL
13DC 7599F2    MOV SBUF,#0F2H ;OFF ONES
13DE D125      ACALL TRANS_DEL
13E0 300405    TST_VENTSEL2:
13E2 7599F0    JNB VEN_SEL,TST_TEMP2

```

```

13D4 7599F3      MOV SBUF.#0F3H      :VENT SEL OFF
13D7 D125        ACALL TRANS_DEL
                  TST_TEMP2:
13D9 303B0A      JNB TEMP.TST_BEEP2
13DC 7599F1      MOV SBUF.#0F1H      :OFF TENS
13DF D125        ACALL TRANS_DEL
13E1 7599F2      MOV SBUF.#0F2H      :OFF ONES
13E4 D125        ACALL TRANS_DEL

                  TST_BEEP2:
13E6 301402      JNB BEEP.OUT
13E9 C2A7        CLR P2.7      :AUDIO OFF
                  OUT:
13EB 758C70      MOV TH0.#70H      :RST TIMERO
13EE D2A9        SETB ETO
13F0 D28C        SETB TRO
13F2 22          RET

                  TIM_SAMP:      ::TIMER 0 INTERRUPT
13F3 C0E0        PUSH ACC      :SAVE SFR'S
13F5 C0F0        PUSH B
13F7 C0D0        PUSH PSW
13F9 758C70      MOV TH0.#70H      :RESET TIMER
13FC D2D3        SETB PSW.3      :SELECT REGISTER BANK 1
13FE C2D4        CLR PSW.4
1400 100204      JBC DIV21,CLEAR
1403 D202        SETB DIV21      :FREQ 100HZ
1405 A167        AJMP RETURN
1407 09          CLEAR: INC RCHG_TIM ;R1
1408 DA2B        DJNZ RDIV10,SAMPLE ;R2
140A 7A0A        MOV RDIV10,#10 ;RESET RDIV10
140C 100B04      JBC DIV22,SET_CLK
140F D20B        SETB DIV22
1411 8135        AJMP SAMPLE

                  SET_CLK:      ::SET .2S CLOCK
1413 D239        SETB CLK
1415 100E02      JBC DIV24,CONT6
1418 D20E        SETB DIV24
141A DB19        CONT6: DJNZ RDIV5,SAMPLE ;R3
141C 7B05        MOV RDIV5,#5 ;FREQ 1 HZ

                  :SILENCE 2 MIN
141E 300608      JNB SIL.CHK_HOLD
1421 C2A7        CLR P2.7      :BUZZER OFF
1423 DE04        DJNZ RSIL_TIM.CHK_HOLD      :?NOT 2 MIN
1425 7E78        MOV RSIL_TIM.#120 :R6, RESET 2 MIN
1427 C206        CLR SIL
                  CHK_HOLD:      ::STOP NEB?
1429 300809      JNB HOLD.SAMPLE
142C DF07        DJNZ RHOLD_TIM.SAMPLE ;R7
142E 7F78        MOV RHOLD_TIM.#120
1430 200602      JB SIL.SAMPLE
1433 D2A7        SETB P2.7      :ON BUZZER

```


-31-

```

1435 C2D3      SAMPLE:      ::READ VENT SIG
1437 C2D4      CLR PSW.3      ;BANK 0
1439 53A0FB    CLR PSW.4
143C D2A3      ANL P2.#11111000B      ;CLEAR MUX ADDRESS
143E          SETB P2.3
143E          ANALOG RVENT_SIG
+143E 00      NOP      ;DELAY TIME FOR MUX
+143F 00      NOP
+1440 00      NOP
+1441 00      NOP
+1442 00      NOP
+1443 C2A3      CLR P2.3      ;START CONVERSION
+1445 00      NOP      ;ALLOW CONV. TIME 5 MICROSEC
+1446 00      NOP
+1447 00      NOP
+1448 A990      MOV RVENT_SIG,P1      ;SAVE DIGITAL OUTPUT
+144A D2A3      SETB P2.3
144C 00      NOP
144D          RUNNING_AVG VENT_LOW,4.RVENT_SIG,VENT_AVG
+          ;CALCULATES RUNNING AVERAGE OF 4 BYTES IN DATA MEMORY
+          ;WITH A LOW ADDRESS OF LODATA. INPUT SIGNAL IS LOCATED
+          ;AT INSIG. AVERAGE OUTPUT IS AT AVG.
+144D C0D0      PUSH PSW
+144F C0E0      PUSH ACC
+1451 C0F0      PUSH B
+1453 C2D3      CLR PSW.3      ;BANK 0
+1455 C2D4      CLR PSW.4
+1457 7468      MOV A,#VENT_LOW      ;SET RO
+1459 2404      ADD A,#4
+145B 14        DEC A
+145C F8        MOV RO,A
+          NEXT10004:
+145D 18        DEC RO
+145E E6        MOV A,@RO      ;SHIFT UP
+145F 08        INC RO
+1460 F6        MOV @RO,A
+1461 18        DEC RO
+1462 B868F8    CJNE RO,#VENT_LOW.NEXT10004      ;LODATA ADDRESS
+1465 E9        MOV A,RVENT_SIG      ;MOV NEW DATA TO VENT_LOW
+1466 75F004    MOV B,#4
+1469 84        DIV AB
+146A F6        MOV @RO,A
+146B 7468      MOV A,#VENT_LOW      ;ADD TO CALC VENT_AVG
+146D 2404      ADD A,#4
+146F 14        DEC A
+1470 F51C      MOV TEMP_STORE,A
+1472 E6        MOV A,@RO
+1473 C8        XCH A,RO
+          NEXT20004:
+1474 C8        XCH A,RO
+1475 08        INC RO
+1476 26        ADD A,@RO
+1477 C8        XCH A,RO
+1478 B51CF9    CJNE A,TEMP_STORE,NEXT20004

```

```

+147B C8      XCH A,R0
+147C F56C    MOV VENT_AVG,A
+147E D0F0    POP B
+1480 D0E0    POP ACC
+1482 D0D0    POP PSW
1484 00       NOP
1485 05A0     INC P2
1487          ANALOG RFLT_FLO
+1487 00      NOP :DELAY TIME FOR MUX
+1488 00      NOP
+1489 00      NOP
+148A 00      NOP
+148B 00      NOP
+148C C2A3    CLR P2.3 :START CONVERSION
+148E 00      NOP :ALLOW CONV. TIME 5 MICROSEC
+148F 00      NOP
+1490 00      NOP
+1491 AA90    MOV RFLT_FLO,P1 :SAVE DIGITAL OUTPUT
+1493 D2A3    SETB P2.3
1495 00      NOP
1496          RUNNING_AVG FLT_FLO_LO,4,RFLT_FLO,FLT_FLO_AVG
+          :CALCULATES RUNNING AVERAGE OF 4 BYTES IN DATA MEMORY
+          :WITH A LOW ADDRESS OF L0DATA. INPUT SIGNAL IS LOCATED
+          :AT INSIG. AVERAGE OUTPUT IS AT AVG.
+1496 C0D0    PUSH PSW
+1498 C0E0    PUSH ACC
+149A C0F0    PUSH B
+149C C2D3    CLR PSW.3 :BANK0
+149E C2D4    CLR PSW.4
+14A0 7440    MOV A,#FLT_FLO_LO :SET R0
+14A2 2404    ADD A,#4
+14A4 14      DEC A
+14A5 F8      MOV R0,A
+          NEXT10006:
+14A6 18      DEC R0
+14A7 E6      MOV A,@R0 :SHIFT UP
+14A8 08      INC R0
+14A9 F6      MOV @R0,A
+14AA 18      DEC R0
+14AB B840F8  CJNE R0,#FLT_FLO_LO,NEXT10006 :L0DATA ADDRESS
+14AE EA      MOV A,RFLT_FLO :MOV NEW DATA TO FLT_FLO_LO
+14AF 75F004  MOV B,#4
+14B2 84      DIV AB
+14B3 F6      MOV @R0,A
+14B4 7440    MOV A,#FLT_FLO_LO :ADD TO CALC FLT_FLO_AVG
+14B6 2404    ADD A,#4
+14B8 14      DEC A
+14B9 F51C    MOV TEMP_STORE,A
+14BB E6      MOV A,@R0
+14BC C8      XCH A,R0
+          NEXT20006:
+14BD C8      XCH A,R0
+14BE 08      INC R0
+14BF 26      ADD A,@R0
+14C0 C8      XCH A,R0

```

```

+14C1 B51CF9    CJNE A,TEMP_STORE,NEXT20006
+14C4 C8        XCH A,R0
+14C5 F544      MOV FLT_FLO_AVG,A
+14C7 D0F0      POP B
+14C9 D0E0      POP ACC
+14CB D0D0      POP PSW
+14CD 00        NOP
+14CE 05A0      INC P2
+14D0          ANALOG RAW_PRESS
+14D0 00        NOP ;DELAY TIME FOR MUX
+14D1 00        NOP
+14D2 00        NOP
+14D3 00        NOP
+14D4 00        NOP
+14D5 C2A3      CLR P2.3 ;START CONVERSION
+14D7 00        NOP ;ALLOW CONV. TIME 5 MICROSEC
+14D8 00        NOP
+14D9 00        NOP
+14DA AB90      MOV RAW_PRESS,P1 ;SAVE DIGITAL OUTPUT
+14DC D2A3      SETB P2.3
+14DE 00        NOP
+14DF          RUNNING_AVG AWP_LO,4,RAW_PRESS,AWP_AVG
+              ;CALCULATES RUNNING AVERAGE OF 4 BYTES IN DATA MEMORY
+              ;WITH A LOW ADDRESS OF LDATA. INPUT SIGNAL IS LOCATED
+              ;AT INSIG. AVERAGE OUTPUT IS AT AVG.
+14DF C0D0      PUSH PSW
+14E1 C0E0      PUSH ACC
+14E3 C0F0      PUSH B
+14E5 C2D3      CLR PSW.3 ;BANK0
+14E7 C2D4      CLR PSW.4
+14E9 7448      MOV A,#AWP_LO ;SET R0
+14EB 2404      ADD A,#4
+14ED 14        DEC A
+14EE F8        MOV R0,A
+              NEXT10008:
+14EF 18        DEC R0
+14F0 E6        MOV A,@R0 ;SHIFT UP
+14F1 08        INC R0
+14F2 F6        MOV @R0,A
+14F3 18        DEC R0
+14F4 B848F8    CJNE R0,#AWP_LO,NEXT10008 ;LDATA ADDRESS
+14F7 EB        MOV A,RAW_PRESS ;MOV NEW DATA TO AWP_LO
+14F8 75F004    MOV B,#4
+14FB 84        DIV AB
+14FC F6        MOV @R0,A
+14FD 7448      MOV A,#AWP_LO ;ADD TO CALC AWP_AVG
+14FF 2404      ADD A,#4
+1501 14        DEC A
+1502 F51C      MOV TEMP_STORE,A
+1504 E6        MOV A,@R0
+1505 C8        XCH A,R0
+              NEXT20008:
+1506 C8        XCH A,R0
+1507 08        INC R0
+1508 26        ADD A,@R0

```

```

+1509 C8      XCH A,R0
+150A B51CF9  CJNE A,TEMP_STORE,NEXT2000B
+150D C8      XCH A,R0
+150E F54C    MOV AWP_AVG,A
+1510 D0F0    POP B
+1512 D0E0    POP ACC
+1514 D0D0    POP PSW
1516 00      NOP
1517 30150A   JNB INSP,NEXT_SAMP
151A E54D     MOV A,AWP_MAX
151C C3      CLR C
151D 954C     SUBB A,AWP_AVG
151F 5003     JNC NEXT_SAMP
1521 854C4D   MOV AWP_MAX,AWP_AVG
NEXT_SAMP:
1524 00      NOP
1525 05A0     INC P2
1527         ANALOG RNEB_FLO
+1527 00      NOP ;DELAY TIME FOR MUX
+1528 00      NOP
+1529 00      NOP
+152A 00      NOP
+152B 00      NOP
+152C C2A3    CLR P2.3 ;START CONVERSION
+152E 00      NOP ;ALLOW CONV. TIME 5 MICROSEC
+152F 00      NOP
+1530 00      NOP
+1531 AC90    MOV RNEB_FLO,P1 ;SAVE DIGITAL OUTPUT
+1533 D2A3    SETB P2.3
1535 00      NOP
1536 EC      MOV A,RNEB_FLO ;R4
1537 C3      CLR C
1538 9432     SUBB A,#50
153A 400E     JC NEGFLD
153C C3      CLR C ;DIV BY 4
153D 13      RRC A
153E C3      CLR C
153F 13      RRC A
1540 2550     ADD A,POSSUM ;SUN POS FLOW
1542 F550     MOV POSSUM,A ;SAVE
1544 500F     JNC CONT1
1546 D20F     SETB FLOW ;OVERFLOW CONDITION
1548 800B     SJMP CONT1
NEGFLD:      ::NEG FLOW
154A 7432     MOV A,#50
154C 9C      SUBB A,RNEB_FLO
154D C3      CLR C ;DIV BY 4
154E 13      RRC A
154F C3      CLR C
1550 13      RRC A
1551 2551     ADD A,NEGSUM
1553 F551     MOV NEGSUM,A ;SAVE
CONT1:
1555 00      NOP
1556 05A0     INC P2

```

```

1558          ANALOG RTEMP
+1558 00      NOP      ;DELAY TIME FOR MUX
+1559 00      NOP
+155A 00      NOP
+155B 00      NOP
+155C 00      NOP
+155D C2A3    CLR P2.3      ;START CONVERSION
+155F 00      NOP      ;ALLOW CONV. TIME 5 MICROSEC
+1560 00      NOP
+1561 00      NOP
+1562 AD90    MOV RTEMP,P1      ;SAVE DIGITAL OUTPUT
+1564 D2A3    SETB P2.3
1566 00      NOP
          RETURN:  ;:RET FROM INT
1567 D0D0    POP PSW
1569 D0F0    POP B
156B D0E0    POP ACC
156D 32      RETI

```

```

156E 103902  SERVICE:  ;:CHK FLOW,SER-REC,BLINK
1571 22      JBC CLK,TEMP_CONT
1572 00      RET
          TEMP_CONT:  ;:CONTROL HEATER
1573 C2D3    CLR PSW.3  ;BANK0
1575 C2D4    CLR PSW.4
1577 ED      MOV A,RTEMP  ;R5
157B B4A00C  CJNE A,#TEMP_HI,NOT_EQ
          HITEMP:  ;:OVER 80C
157B C281    CLR P0.1  ;HEAT OFF
157D C23A    CLR HEAT
157F D220    SETB L35  ;HI TEMP LED
1581 852599  MOV SBUF,LED3
1584 D20C    SETB ALM
1586 22      RET
1587 5022    NOT_EQ: JNC HI_TEMP ;RTEMP>TEMP_HI
1589 E511    MOV A,TEMP_SET
158B B42804  CJNE A,#40,HEAT_CHK
158E C281    CLR P0.1  ;HEAT OFF
1590 A1B5    AJMP FLO_TST
          HEAT_CHK:  ;:CHK HEAT BIT
1592 203A0C  JB HEAT,SW_OFF
1595 C3      CLR C
1596 940A    SUBB A,#10  ;LOW LIMIT
1598 9D      SUBB A,RTEMP ;R5
1599 401A    JC FLO_TST  ;?LEAVE OFF?
159B D281    SETB P0.1  ;TURN ON
159D D23A    SETB HEAT
159F A1B5    AJMP FLO_TST
          SW_OFF:
15A1 240A    ADD A,#10  ;UPPER LIMIT
15A3 C3      CLR C
15A4 9D      SUBB A,RTEMP
15A5 500E    JNC FLO_TST  ;?LEAVE ON?

```

```

15A7 C281      CLR PO.1  :TURN OFF
15A9 C23A      CLR HEAT
                HI_TEMP:  ::TEMP ALARM
                SETB L35  :HI TEMP LED
15AB D220      MOV SBUF,LED3
15AD 852599    ACALL TRANS_DEL
1580 D125      SETB ALM
1582 D20C      RET
1584 22        FLO_TST:  ::TEST NEB FLOW
                JB WAIT,CHK_SERPORT
15B5 200070    SETB PSW.3  ;BANK1
15B8 D2D3      CLR PSW.4
15BA C2D4      JBC FLOW,FLO
15BC 100F1C    MOV A,POSSUM
15BF E550      CLR C
15C1 C3        SUBB A,NEGSUM ;CALC SFLO
15C2 9551      JNC CONT2
15C4 5004      DJNZ ROFF_TIM,CONT4
15C6 DD17      AJMP NOFLO_ALM
15C8 A1F7      CONT2:
                MOV B,A  ;SAVE SFLO=POS-NEG
15CA F5F0      SUBB A,#NOFLO_TH  :SFLO-THRESH
15CC 948C      JNC CONT3
15CE 5004      NOFLO:  DJNZ ROFF_TIM,CONT3
15D0 DD02      AJMP NOFLO_ALM
15D2 A1F7      CONT3:
                MOV A,B  ;SFLO
15D4 E5F0      CLR C
15D6 C3        SUBB A,#FLO_TH  ;SFLO-THRESH
15D7 942D      JC CONT4  ;?SFLO<THRESH
15D9 4004      FLO:  DJNZ RON_TIM,CONT4
15DB DC02      AJMP FLO_ALM
15DD C10E      CONT4:  ::CHECK TIME
                MOV POSSUM,#0  ;RESET FLOW SUM
15DF 755000    MOV NEGSUM,#0
15E2 755100    DJNZ ONTIMER,CHK_OFFTIM
15E5 D51405    MOV ONTIMER,#FLOTIM
15E8 75140B    MOV RON_TIM,#FLOTIM
15EB 7C0B      CHK_OFFTIM:
                DJNZ OFFTIMER,CHK_SERPORT
15ED D51538    MOV OFFTIMER,#NOFLOTIM
15F0 751532    MOV ROFF_TIM,#NOFLOTIM
15F3 7D32      AJMP CHK_SERPORT
15F5 C128      NOFLO_ALM:- :?NEB OFF > 10S
                MOV POSSUM,#0
15F7 755000    MOV NEGSUM,#0
15FA 755100    MOV OFFTIMER,#NOFLOTIM
15FD 751532    MOV ROFF_TIM,#NOFLOTIM
1600 7D32      SETB BEEP
1602 D214      SETB ALM
1604 D20C      SETB L24  :NO FLOW LED
1606 D234      MOV SBUF,LED2
1608 852699    ACALL TRANS_DEL
160B D125      RET
160D 22

```

-37-

```

160E 755000      FLO_ALM:      ;:NES IN : 2.2S
1611 755100      MOV POSSUM,#0
1614 75140B      MOV NEGSUM,#0
1617 7C0B        MOV ONTIMER,#FLOCTIM
1619 D20C        SETB ALM      ;FLAG
161B D237        SETB L27      ;CONT FLOW ALM
161D 852699      MOV SBUF,LED2
1620 D125        ACALL TRANS_DEL
1622 22          RET

1623 613F        BLINK_BEEP1:  AJMP BLINK_BEEP
1625 0219BE      TRANS_DEL:    ;:DELAY 2.25MS.CC=00E-
                                LJMP TRANS_DEL1

                                CHK_SERPORT:  ;:NEW CHAR REC?
1628 3098FB      JNB RI,BLINK_BEEP1
162B C298        CLR RI
162D C2A9        CLR ETO      ;DISABLE TIMER 0 INT
162F C28C        CLR TRO      ;DISABLE TIMER 0
1631 E599        MOV A,SBUF    ;READ CODE RECEIVED
1633 C4          SWAP A
1634 23          RL A          ;MULTIPLY BY 2
1635 901639      MOV DPTR,#JUMP_TB1E1
1638 73          JMP @A+DPTR
1639 C17D        JUMP_TB1E1:  AJMP CASE0      ;KEYS SET
163B C1F4        AJMP CASE1      ;NES. ALL
163D E19F        AJMP CASE2      ;SELF TEST
163F E19D        AJMP CASE3      ;NO ACTION
1641 E126        AJMP CASE4      ;KEY SET
1643 E1A1        AJMP CASE5      ;DISABLE TRO
1645 C15D        AJMP CASE61     ;KEY SET
1647 C161        AJMP CASE71     ;NO ACTION
1649 E169        AJMP CASE8      ;CHANGE AL
164B C165        AJMP CASE91     ;DISABLE TRO
164D C169        AJMP CASEA1     ;KEY BEEP
164F C16D        AJMP CASEB1     ;NO ACTION
1651 C171        AJMP CASEC1     ;ENTER
1653 C175        AJMP CASED1     ;DISABLE TRO
1655 C179        AJMP CASEE1     ;KEY BEEP
1657 C15A        AJMP CASEF      ;NO ACTION
1659 00          NOP
                                CASEF:  ;NO ACTION
165A 613F        AJMP BLINK_BEEP
165C 00          NOP
165D 02186D      CASE61:  LJMP CASE6
1660 00          NOP
1661 021867      CASE71:  LJMP CASE7
1664 00          NOP
1665 021818      CASE91:  LJMP CASE9
1668 00          NOP
1669 02187A      CASEA1:  LJMP CASEA
166C 00          NOP
166D 02186A      CASEB1:  LJMP CASEB

```

```

1670 00      NOP
1671 021843  CASEC1: LJMP CASEC
1674 00      NOP
1675 0218D7  CASED1: LJMP CASED
1678 00      NOP
1679 021955  CASEE1: LJMP CASEE
167C 00      NOP

CASE0:  ;:TEMP SET
167D 203B19  JB TEMP,NEW_TEMP
1680 D23B    SETB TEMP
1682 E511    MOV A,TEMP_SET
1684 B42820  CJNE A,#40,DISPLAY_TEMP
OFF_STATE:  ;:LCD "-" "-"
1687 7599F0  MOV SBUF,#0F0H ;HUNS BLINK
168A D125    ACALL TRANS_DEL
168C 7599A1  MOV SBUF,#0A1H ;TENS "-"
168F D125    ACALL TRANS_DEL
1691 7599A2  MOV SBUF,#0A2H ;ONES "-"
1694 D125    ACALL TRANS_DEL
1696 613F    AJMP BLINK_BEEP
1698 00      NOP
NEW_TEMP:  ;:NEXT SET TEMP
1699 E511    MOV A,TEMP_SET
169B B47805  CJNE A,#120,CALC_TEMP
169E 751128  MOV TEMP_SET,#40
16A1 C187    AJMP OFF_STATE

CALC_TEMP:
16A3 2414    ADD A,#20
16A5 F511    MOV TEMP_SET,A

DISPLAY_TEMP:
16A7 C3      CLR C
16A8 13      RRC A ;DIV BY 2
16A9         BINARY_BCD DEC_HUN,DEC_TEN ;CONVERTS BYTE LOCATED IN DEC_TEN TO BINARY
+           ;AND STORES RESULT IN DEC_HUN AND ONE.
+
+16A9 752900  MOV DEC_HUN,#0 ;CLEAR DEC_HUN
+16AC 752A00  MOV DEC_TEN,#0
+16AF 752B00  MOV DEC_ONE,#0
+           CALC_HUN0011: ;:SUBTRACT
+16B2 F5F0    MOV B,A
+           NEXTSUB10011:
+16B4 C3      CLR C
+16B5 9464    SUBB A,#100
+16B7 4006    JC CALC_TEN0011
+16B9 0529    INC DEC_HUN
+16BB F5F0    MOV B,A ;SAVE
+16BD 80F5    SJMP NEXTSUB10011
+           CALC_TEN0011: ;:SUBTRACT
+16BF E5F0    MOV A,B
+           NEXTSUB20011:
+16C1 C3      CLR C
+16C2 940A    SUBB A,#10

```



```

+16C4 4006      JC CALC_ONE0011
+16C6 052A      INC DEC_TEN
+16C8 F5F0      MOV B,A
+16CA 80F5      SJMP NEXTSUB20011
+              CALC_ONE0011:
+16CC 85F02B     MOV DEC_ONE,B
+16CF E529       MOV A,DEC_HUN
+16D1 700A       JNZ BCD_OUT0011
+16D3 75290F     MOV DEC_HUN,#0FH ;BLANK
+16D6 E52A       MOV A,DEC_TEN
+16D8 7003       JNZ BCD_OUT0011
+16DA 752A0F     MOV DEC_TEN,#0FH ;BLANK
+              BCD_OUT0011:
+16DD 7599F0     MOV SBUF,#0FH ;HUN BLANK
16E0 D125       ACALL TRANS_DEL
16E2 E52A       MOV A,DEC_TEN
16E4 C4          SWAP A
16E5 4401        ORL A,#01H
16E7 F512        MOV TEMP_DEC,A ;SAVE TENS
16E9 F599        MOV SBUF,A
16EB D125       ACALL TRANS_DEL
16ED 759902     MOV SBUF,#02H ;ONES
16F0 D125       ACALL TRANS_DEL
16F2 613F       AJMP BLINK_BEEP

16F4 D2D3       CASE1: ;:NEBULIZER HOLD
16F6 C2D4       SETB PSW.3 ;BANK1
16F8 100810     CLR PSW.4
16FB D208       JBC HOLD,HOLD_OFF
16FD D214       SETB HOLD ;HOLD FLAG
16FF D235       SETB L25 ;NEB HOLD LED
1701 852699     MOV SBUF,LED2
1704 D125       ACALL TRANS_DEL
1706 43A070     ORL P2,#01110000B ;OFF VALVES
1709 800B       SJMP HOLD_OUT
              HOLD_OFF:
170B C208       CLR HOLD ;HOLD FLAG
170D C214       CLR BEEP
170F C235       CLR L25 ;OFF HOLD LED
1711 852699     MOV SBUF,LED2
1714 D125       ACALL TRANS_DEL
              HOLD_OUT:
1716 7F78       MOV RHOLD_TIM,#120 ;R7 RESET
1718 D200       SETB WAIT
171A D21E       SETB L16 ;WAIT LED
171C 852399     MOV SBUF,LED1
171F D125       ACALL TRANS_DEL
1721 752F00     MOV THREE_CYCLE,#0
1724 613F       AJMP BLINK_BEEP

1726 43A070     CASE4: ;:SELECT VENT
1728 D204       ORL P2,#01110000B ;VALVES OFF
172B D200       SETB VEN_SEL
172E D200       SETB WAIT

```

```

172D 752F00      MOV THREE_CYCLE.#0
1730 D21E        SETB L16 :WAIT
1732 852399      MOV SBUF,LED1
1735 D125        ACALL TRANS_DEL
1737 C2D3        CLR PSW.3 :BANK0
1739 C2D4        CLR PSW.4
173B EE          MOV A,RVENT :R4, INC. VENT. NO.
173C 2410        ADD A,#10H
173E B44302      CJNE A,#43H,SEE_VENT
1741 7413        MOV A,#13H ;RESET #1
                  SEE_VENT:
1743 FE          MOV RVENT,A
1744 8E99        MOV SBUF,RVENT ;DISPLAY NEW NUMBER
1746 D125        ACALL TRANS_DEL
1748 00          NOP
1749 EE          MOV A,RVENT ;LOOK UP THRESHOLDS FOR VENTILATOR SELECTED
174A C4          SWAP A
174B 540F        ANL A,#0FH ;CLEAR ADDRESS
174D 23          RL A ;MULT. BY 2
174E F5F0        MOV B,A ;SAVE
1750 F15D        ACALL VENT_TBLE
1752 F51B        MOV VENT_HI,A ;STORE UPPER THRESH
1754 E5F0        MOV A,B
1756 14          DEC A
1757 F15D        ACALL VENT_TBLE
1759 F51A        MOV VENT_LO,A ;STORE LOWER THRESH
175B 613F        AJMP BLINK_BEEP

175D 83          VENT_TBLE: MOVC A,@A+PC
175E 22          RET ;THRESHOLDS
175F 3B 45 81    DB 3BH,45H,81H,86H,3BH,45H ;SERVO LO 2.3V, HI 2.7V
1762 86 3B 45    ;PB7200 LO 5.05V, HI 5.25V, HAM LO 2.3V, HI 2.7V

CASEB1: ::INITIALIZATION ENTRY
1765 C2A9        CLR ETO
1767 C28C        CLR TRO

CASEB: ::CHANGE VOLUME
1769 D203        SETB VOL_CHG
176B E528        MOV A,CHG_VOL
176D C4          SWAP A
176E 23          RL A
176F F5F0        MOV B,A
1771 F18F        ACALL CHGVOL_TBLE
1773 F519        MOV SET_CHGTIM,A
1775 E5F0        MOV A,B
1777 14          DEC A
177B F18F        ACALL CHGVOL_TBLE
177A F528        MOV CHG_VOL,A
177C 852899      MOV SBUF,CHG_VOL
177F D125        ACALL TRANS_DEL
1781 D200        SETB WAIT
1783 752F00      MOV THREE_CYCLE.#0
1786 D21E        SETB L16

```

```

1788 852399      MOV SBUF.LED1
1788 D125        ACALL TRANS_DEL
178D 613F        AJMP BLINK_BEEP
                  CHGVOL_TBLE:  ;;SELECT NEW VOL
178F 83          MOVC A,EA+PC
1790 22          RET
1791 20 14 40    DB 20H,20,40H,40,0,0,60H,60,0,0,10H,10
1794 28 00 00    DB 60 3C 00 00 10 0A
                  ;SHIFT TO NEW VOLUME

                  CASE3:  ;;NO ACTION
179D 613F        AJMP BLINK_BEEP

                  CASE2: ;NO ACTION
179F 613F        AJMP BLINK_BEEP

                  CASE5:  ;;DISPLAY TEMP
17A1 10105B      JBC SEE_TEMP,RESTORE_VOL1
17A4 D210        SETB SEE_TEMP
17A6 C2D3        CLR PSW.3  ;BANK0
17A8 C2D4        CLR PSW.4
17AA ED          MOV A,RTEMP ;R5
17AB C3          CLR C
17AC 13          RRC A  ;DIV BY 2
17AD             BINARY_BCD DEC_HUN,DEC_TEN,DEC_ONE
+                ;CONVERTS BYTE LOCATED IN ACC TO DECIMAL
+                ;AND STORES RESULT IN DEC_HUN, DEC_TEN AND ONE.
+17AD 752900      MOV DEC_HUN,#0  ;CLEAR REGISTERS
+17B0 752A00      MOV DEC_TEN,#0
+17B3 752B00      MOV DEC_ONE,#0
+                CALC_HUN0012:  ;;SUBTRACT 100
+17B6 F5F0       MOV B,A
+                NEXTSUB10012:
+17B8 C3          CLR C
+17B9 9464        SUBB A,#100
+17BB 4006        JC CALC_TEN0012
+17BD 0529        INC DEC_HUN
+17BF F5F0       MOV B,A  ;SAVE
+17C1 80F5        SJMP NEXTSUB10012
+                CALC_TEN0012:  ;;SUBTRACT 10
+17C3 E5F0       MOV A,B
+                NEXTSUB20012:
+17C5 C3          CLR C
+17C6 940A        SUBB A,#10-
+17C8 4006        JC CALC_ONE0012
+17CA 052A        INC DEC_TEN
+17CC F5F0       MOV B,A
+17CE 80F5        SJMP NEXTSUB20012
+                CALC_ONE0012:
+17D0 85F02B      MOV DEC_ONE,B
+17D3 E529        MOV A,DEC_HUN
+17D5 700A        JNZ BCD_OUT0012
+17D7 75290F      MOV DEC_HUN,#0FH  ;BLANK
+17DA E52A        MOV A,DEC_TEN

```

```

+17DC 7003      JNZ BCD_OUT0012
+17DE 752A0F    MOV DEC_TEN,#0FH      :BLANK
+          BCD_OUT0012:
17E1 00        NOP
17E2 E529      MOV A,DEC_HUN
17E4 C4        SWAP A
17E5 F599      MOV SBUF,A
17E7 D125      ACALL TRANS_DEL
17E9 E52A      MOV A,DEC_TEN
17EB C4        SWAP A
17EC 4401      ORL A,#01H
17EE F599      MOV SBUF,A
17F0 D125      ACALL TRANS_DEL
17F2 E52B      MOV A,DEC_ONE
17F4 C4        SWAP A
17F5 4402      ORL A,#02H
17F7 F599      MOV SBUF,A
17F9 121625    LCALL TRANS_DEL
17FC 02133F    LJMP BLINK_BEEP

17FF C2D3      RESTORE_VOL1:  ;:DISPLAY VOL
1801 D2D4      CLR PSW.3  ;BANK2
1803 852899    SETB PSW.4
1806 121625    MOV SBUF,CHG_VOL
1809 759901    LCALL TRANS_DEL
180C 121625    MOV SBUF,#01H
180F 759902    LCALL TRANS_DEL
1812 121625    MOV SBUF,#02H
1815 02133F    LCALL TRANS_DEL
1818 101113    OUT_TEMP:
181B D211      LJMP BLINK_BEEP

181D 852C99    CASE9:  ;:DISPLAY FLT LOAD
1820 121625    JBC SEE_LD,RESTORE_VOL2
1823 852D99    SETB SEE_LD
1826 121625    MOV SBUF,FLTLTLD_HUN
1829 852E99    LCALL TRANS_DEL
182C 0140      MOV SBUF,FLTLTLD_TEN
182E 852899    LCALL TRANS_DEL
1831 121625    MOV SBUF,FLTLTLD_ONE
1834 759901    AJMP OUT_DISPLD
1837 121625    RESTORE_VOL2:  ;:DISPLAY VOL
183A 759902    MOV SBUF,CHG_VOL
183D 121625    LCALL TRANS_DEL
1840 02133F    MOV SBUF,#01H
1843 C204      LCALL TRANS_DEL
1845 C203      MOV SBUF,#02H
1847 C238      LCALL TRANS_DEL
              OUT_DISPLD:
              LJMP BLINK_BEEP

              CASEC:  ;:ENTER KEY
              CLR VEN_SEL
              CLR VOL_CHG
              CLR TEMP

```

```

1849 C2D3      CLR PSW.3  ;BANK0
1848 C2D4      CLR PSW.4
184D 8E99      MOV SBUF,RVENT
184F 121625    LCALL TRANS_DEL
1852 852899    MOV SBUF,CHG_VOL  ;SET HUNS
1855 121625    LCALL TRANS_DEL
1858 759901    MOV SBUF,#01H  ;SET TENS
185B 121625    LCALL TRANS_DEL
185E 759902    MOV SBUF,#02H  ;SET ONES
1861 121625    LCALL TRANS_DEL
1864 02133F    LJMP BLINK_BEEP

CASE7:        ;:NO ACTION
1867 02133F    LJMP BLINK_BEEP

CASEB:        ;:NO ACTION
186A 02133F    LJMP BLINK_BEEP

CASE6:        ;:SIL ALM 2 MIN
186D D2D3      SETB PSW.3  ;BANK1
186F C2D4      CLR PSW.4
1871 C2A7      CLR P2.7   ;OFF BUZZER
1873 D206      SETB SIL    ;SILENCE FLAG
1875 7E78      MOV RSIL_TIM,#120  ;R6.TWC MIN. TIME
1877 02133F    LJMP BLINK_BEEP

CASEA:        ;:ALM RST
187A 75A078    MOV P2,#78H  ;OUTPUTS OFF
187D 752000    MOV 20H,#0   ;CLEAR BITS
1880 752100    MOV 21H,#0
1883 752200    MOV 22H,#0
1886 752700    MOV 27H,#0
1889 D200      SETB WAIT
188B D21E      SETB L16  ;WAIT
188D C21D      CLR L15  ;FILT CHANGE
188F C21F      CLR L17  ;LOFLOW
1891 852399    MOV SBUF,LED1
1894 31BE      ACALL TRANS_DEL1
1896 852899    MOV SBUF,CHG_VOL ;NORMAL LCD
1899 31BE      ACALL TRANS_DEL1
189B 759901    MOV SBUF,#01H
189E 31BE      ACALL TRANS_DEL1
18A0 759902    MOV SBUF,#02H
18A3 31BE      ACALL TRANS_DEL1
18A5 C2D3      CLR PSW.3  ;BANK0
18A7 C2D4      CLR PSW.4
18A9 8E99      MOV SBUF,RVENT ;R1
18AB 31BE      ACALL TRANS_DEL1
18AD 53260F    ANL LED2,#0FH ;OFF
18B0 852699    MOV SBUF,LED2
18B3 31BE      ACALL TRANS_DEL1
18B5 C22C      CLR L34  ;HI PRESS
18B7 852599    MOV SBUF,LED3
18BA 31BE      ACALL TRANS_DEL1
18BC 752F00    MOV THREE_CYCLE,#0  ;RESET

```

-44-

```

18BF 0210 SETB PSW.3 :BANK1
18C1 0210 CLR PSW.4
18C3 7010 MOV RON_TIM,#0
18C5 7010 MOV ROFF_TIM,#0
18C7 755100 MOV POSSUM,#0
18CA 755100 MOV NEGSUM,#0
18CD 755070 MOV TH0,#70H :RST TIMER
18D0 755227 MOV IE,#87H :SET ETO
18D3 755250 MOV TCON,#50H :SET TRO
18D6 22 RET

```

```

CASED:  ::DISPLAY PIP
        ;MULTIPLY BY SCALE FACTOR OF 5/8, CONVERT TO BCD
        ;AND DISPLAY PIP. RETURN TO VOLUME DISPLAY WHEN
        ;SWITCH IS PRESSED A SECOND TIME.

```

```

18D7 100963 JBC SEE_PIP,LCD_VOL
18DA 0207 SETB SEE_PIP
18DC E54E MOV A,PIP_STORE
18DE 75F005 MOV B,#5
18E1 A4 MUL AB :MSB IN B
18E2 05F0 XCH A,B :RRC 3 TIMES TO DIVIDE BY 8
18E4 13 RRC A :MSB IN A
18E5 05F0 XCH A,B :LSB IN A
18E7 13 RRC A
18E8 03 CLR C :SECOND ROTATION
18E9 05F0 XCH A,B
18EB 13 RRC A
18EC 05F0 XCH A,B
18EE 13 RRC A
18EF 03 CLR C :THIRD ROTATION
18F0 05F0 XCH A,B
18F2 13 RRC A
18F3 05F0 XCH A,B
18F5 13 RRC A
18F6 941E SUBB A,#14H :ZERO OFFSET
18F8 BINARY_BCD DEC_HUN,DEC_TEN,DEC_ONE
        ;CONVERTS BYTE LOCATED IN ACC TO DECIMAL
        ;AND STORES RESULT IN DEC_HUN, DEC_TEN AND ONE.
+
+
+18F8 752900 MOV DEC_HUN,#0 :CLEAR REGISTERS
+18FB 752A00 MOV DEC_TEN,#0
+18FE 752B00 MOV DEC_ONE,#0
+
CALC_HUN0013: ::SUBTRACT 100
MOV B,A
NEXTSUB10013:
CLR C
SUBB A,#100
JC CALC_TEN0013
INC DEC_HUN
MOV B,A :SAVE
SJMP NEXTSUB10013
CALC_TEN0013: ::SUBTRACT 10
MOV A,B
NEXTSUB20013:
CLR C

```

```

+1911 940A      SUBB A,#10
+1913 4006      JC CALC_ONE0013
+1915 052A      INC DEC_TEN
+1917 F5F0      MOV B,A
+1919 80F5      SJMP NEXTSUB20013
+              CALC_ONE0013:
+191B 85F02B    MOV DEC_ONE,B
+191E E529      MOV A,DEC_HUN
+1920 700A      JNZ BCD_OUT0013
+1922 75290F    MOV DEC_HUN,#0FH :BLANK
+1925 E52A      MOV A,DEC_TEN
+1927 7003      JNZ BCD_OUT0013
+1929 752A0F    MOV DEC_TEN,#0FH :BLANK
+              BCD_OUT0013:
+              MOV A,DEC_HUN :DISPLAY PIP
192C E529      SWAP A
192E C4         MOV SBUF,A
192F F599      ACALL TRANS_DEL1
1931 31BE      MOV A,DEC_TEN
1933 E52A      SWAP A
1935 C4         ORL A,#01H
1936 4401      MOV SBUF,A
1938 F599      ACALL TRANS_DEL1
193A 31BE      MOV A,DEC_ONE
193C E52B      SWAP A
193E C4         ORL A,#02H
193F 4402      MOV SBUF,A
1941 F599      SJMP OUTPIP
1943 800D      LCD_VOL: :DISPLAY VOL
1945 852899    MOV SBUF,CHG_VOL
1948 31BE      ACALL TRANS_DEL1
194A 759901    MOV SBUF,#01H
194D 31BE      ACALL TRANS_DEL1
194F 759902    MOV SBUF,#02H
1952 02133F    OUTPIP:
                LJMP BLINK_BEEP

                CASEE: :ALM TEST
                :PUSH SW TO TEST & PUSH TO RETURN
1955 100A33    JBC ALM_TST,NORMAL
1958 D20A      SETB ALM_TST
195A D2A7      SETB P2.7 :ON BUZZER
195C 7480      MOV A,#80H
195E F599      MOV SBUF,A :HUNS LCD TEST
1960 1219BE    LCALL TRANS_DEL1
1963 04        INC A :TENS
1964 F599      MOV SBUF,A
1966 1219BE    LCALL TRANS_DEL1
1969 04        INC A :ONES
196A F599      MOV SBUF,A
196C 1219BE    LCALL TRANS_DEL1
196F 04        INC A :VENT #
1970 F599      MOV SBUF,A
1972 1219BE    LCALL TRANS_DEL1
1975 74F4      MOV A,#0F4H :LED1 TEST

```

```

1977 F599      MOV SBUF,A
1979 12198E    LCALL TRANS_DEL1
197C 04        INC A      ;LED2
197D F599      MOV SBUF,A
197F 12198E    LCALL TRANS_DEL1
1982 04        INC A
1983 F599      MOV SBUF,A ;LED3
1985 12198E    LCALL TRANS_DEL1
1988 02198A    LJMP OUT_TST
              NORMAL:  ;:NORMAL DISPLAY
198B C2A7      CLR P2.7  ;RESTORE ALARM & DISPLAYS
198D C2D3      CLR PSW.3  ;BANK0
198F C2D4      CLR PSW.4
1991 852899    MOV SBUF,CHG_VOL
1994 12198E    LCALL TRANS_DEL1
1997 759901    MOV SBUF,#01H
199A 12198E    LCALL TRANS_DEL1
199D 759902    MOV SBUF,#02H
19A0 12198E    LCALL TRANS_DEL1
19A3 8E99      MOV SBUF,RVENT
19A5 12198E    LCALL TRANS_DEL1
19A8 852399    MOV SBUF,LED1
19AB 12198E    LCALL TRANS_DEL1
19AE 852699    MOV SBUF,LED2
19B1 12198E    LCALL TRANS_DEL1
19B4 852599    MOV SBUF,LED3
19B7 12198E    LCALL TRANS_DEL1
              OUT_TST:
19BA 02133F    LJMP BLINK_BEEP
19BD 00        NOP

              TRANS_DEL1:  ;:DELAY 2.25MS,CC=80EH
19BE D51DFD    DJNZ DIVIDE1,TRANS_DEL1 ;COUNT 255
19C1 751DFF    MOV DIVIDE1,#0FFH ;RESET
19C4 D51EF7    DJNZ DIVIDE2,TRANS_DEL1 ;COUNT 4
19C7 751E04    MOV DIVIDE2,#04H ;RESET
19CA 22        RET
19CB 00        NOP

              MAN_SW:  ;:ON VALVES
19CC C0E0      PUSH ACC
19CE C0D0      PUSH PSW
19D0 C2A8      CLR EX0  ;DISABLE INT
19D2 53A08F    ANL P2,#10001111B ;ON VALVES
19D5 12156E    HOLDIT: LCALL SERVICE
19D8 30B2FA    JNB P3.2,HOLDIT
19DB D200      SETB WAIT
19DD D21E      SETB L16 ;WAIT LED
19DF 852399    MOV SBUF,LED1
19E2 31BE      ACALL TRANS_DEL1
19E4 43A070    ORL P2,#01110000B ;OFF VALVES
19E7 752F00    MOV THREE_CYCLE,#00H
19EA D2A8      SETB EX0 ;ENABLE INTO
19EC D0DC      POP PSW
19EE D0E0      POP ACC

```


19F0 32

RETI

19F1
1000;%E
ENDS :CODE SEGMENT
END BEGIN

;%T	Symbol Name	Type	Value
	ALARM	L	112F
	ALARM1	L	11A8
	ALARM2	L	12A4
	ALM	B	000C
	ALM_TST	B	000A
	ANALOG	M	0000
	AWP_AVG	D	004C
	AWP_LO	D	0048
	AWP_MAX	D	004D
	BANK0	U	0000
	BCD_OUT0011	L	16DD
	BCD_OUT0012	L	17E1
	BCD_OUT0013	L	192C
	BEEP	B	0014
	BEGIN	L	1000
	BINARY_BCD	M	0000
	BLINK_BEEP	L	133F
	BLINK_BEEP1	L	1623
	CALC_HUN0011	L	1682
	CALC_HUN0012	L	17B6
	CALC_HUN0013	L	1901
	CALC_ONE0011	L	16CC
	CALC_ONE0012	L	17D0
	CALC_ONE0013	L	191B
	CALC_PIP	L	115D
	CALC_TEMP	L	16A3
	CALC_TEN0011	L	168F
	CALC_TEN0012	L	17C3
	CALC_TEN0013	L	190E
	CASE0	L	167D
	CASE1	L	16F4
	CASE2	L	179F
	CASE3	L	179D
	CASE4	L	1726
	CASE5	L	17A1
	CASE6	L	186D
	CASE61	L	165D
	CASE7	L	1867
	CASE71	L	1661
	CASE8	L	1769
	CASE81	L	1765
	CASE9	L	181B
	CASE91	L	1665
	CASEA	L	187A
	CASEA1	L	1669
	CASEB	L	186A
	CASEB1	L	166D
	CASEC	L	1843
	CASEC1	L	1671
	CASED	L	18D7
	CASED1	L	1675
	CASEE	L	1955

CASEE1	L 1679
CASEF	L 165A
CHARGE	L 11B4
CHGVOL_TBLE	L 178F
CHG_VOL	D 002B
CHK_AWP	L 1107
CHK_CHGTIM	L 11E6
CHK_DPTHRESH	L 1242
CHK_EDEXH	L 12A7
CHK_EDEXH1	L 123F
CHK_EXH	L 1100
CHK_HOLD	L 1429
CHK_LED21	L 1358
CHK_LED22	L 13A9
CHK_LED31	L 1363
CHK_LED32	L 13B4
CHK_OFFTIM	L 15ED
CHK_PEAK	L 1150
CHK_SERPORT	L 162B
CHK_SIL	L 1134
CHK_VOL	L 11C6
CHK_VOL1	L 136E
CHK_VOL2	L 13BF
CHK_WAIT	L 130B
CHK_WAIT1	L 11E3
CLEAR	L 1407
CLK	B 0039
CLOG1	B 0016
CLOG2	B 0017
CLOG_HI	D 0046
CLOG_LO	D 0045
CONT	L 113C
CONT1	L 1555
CONT2	L 15CA
CONT3	L 15D4
CONT4	L 15DF
CONT5	L 10D2
CONT6	L 141A
DEC_HUN	D 0029
DEC_ONE	D 002B
DEC_TEN	D 002A
DEL1	B 0012
DELAY1	L 10C6
DELAY2	L 10CB
DELAYS	L 1122
DEL_4TENTHS	B 0013
DISPLAY_TEMP	L 16A7
DIV21	B 0002
DIV22	B 000B
DIV23	B 003B
DIV24	B 000E
DIVIDE1	D 001D
DIVIDE2	D 001E
END_DEL	L 10D0
EOI	L 10EB

EXH	B 0001
FIFO	M 0E84
FILTAWP_THRESH	I 0037
FILTDP_THRESH	I 008D
FIRST_SAMP	L 1220
FLO	L 15DB
FLOTIM	I 000B
FLOW	B 000F
FLO_ALM	L 160E
FLO_TH	I 002D
FLO_TST	L 15B5
FLTFLD_AVG	D 0044
FLTFLD_LD	D 0040
FLTLD25	D 0055
FLTLD50	D 0056
FLTLD75	D 0057
FLTLD_HUN	D 002C
FLTLD_ONE	D 002E
FLTLD_TEN	D 002D
FLT_LD	L 1225
GO_ON	L 1339
HEAT	B 003A
HEAT_CHK	L 1592
HIPRESS	L 11A3
HITEMP	L 157B
HI_TEMP	L 15A8
HOLD	B 000B
HOLDIT	L 19D5
HOLD_OFF	L 170B
HOLD_OUT	L 1716
INC3	L 1336
INIT1	L 1032
INITIALIZE	L 1030
INSP	B 0015
JUMP_TB1E1	L 1639
L14	B 001C
L15	B 001D
L16	B 001E
L17	B 001F
L24	B 0034
L25	B 0035
L26	B 0036
L27	B 0037
L34	B 002C
L35	B 0020
LCD_VOL	L 1945
LED1	D 0023
LED2	D 0026
LED3	D 0025
MAIN_LOOP	L 10D8
MAN_SW	L 19CC
NEGFLD	L 154A
NEGSUM	D 0051
NEW_TEMP	L 1699
NEXT10001	L 116D

NEXT10002	. . . . .	L 12C9
NEXT10004	. . . . .	L 145D
NEXT10006	. . . . .	L 14A6
NEXT10008	. . . . .	L 14EF
NEXT20001	. . . . .	L 1185
NEXT20002	. . . . .	L 12E1
NEXT20004	. . . . .	L 1474
NEXT20006	. . . . .	L 148D
NEXT20008	. . . . .	L 1506
NEXTSUB10011	. . . . .	L 1684
NEXTSUB10012	. . . . .	L 17B8
NEXTSUB10013	. . . . .	L 1903
NEXTSUB20011	. . . . .	L 16C1
NEXTSUB20012	. . . . .	L 17C5
NEXTSUB20013	. . . . .	L 1910
NEXT_SAMP	. . . . .	L 1524
NOFLO	. . . . .	L 15D0
NOFLOTIM.	. . . . .	I 0032
NOFLO_ALM	. . . . .	L 15F7
NOFLO_TH.	. . . . .	I 008C
NORMAL.	. . . . .	L 198B
NOT_EQ.	. . . . .	L 1587
OFFTIMER.	. . . . .	D 0015
OFF_ALM	. . . . .	B 000D
OFF_STATE	. . . . .	L 1687
ONTIMER	. . . . .	D 0014
OUT	. . . . .	L 13EB
OUT1.	. . . . .	L 133C
OUTPIP.	. . . . .	L 1952
OUT_DISPLD.	. . . . .	L 1840
OUT_TEMP.	. . . . .	L 1815
OUT_TST	. . . . .	L 19BA
PATINSP_THRESH.	. . . . .	I 0008
PAT_INSP.	. . . . .	L 12F6
PEEP_AVG.	. . . . .	D 0063
PEEP_LO	. . . . .	D 0060
PIP_AVG	. . . . .	D 005B
PIP_LO.	. . . . .	D 0058
PIP_STORE	. . . . .	D 004E
PIP_THRESH.	. . . . .	I 00E0
POSSUM.	. . . . .	D 0050
RAW_PRESS	. . . . .	R 0003
RCHG_TIM.	. . . . .	R 0001
RDIV10.	. . . . .	R 0002
RDIV5	. . . . .	R 0003
RESTORE_VOL1.	. . . . .	L 17FF
RESTORE_VOL2.	. . . . .	L 182E
RETURN.	. . . . .	L 1567
RFLT_FLO.	. . . . .	R 0002
RHOLD_TIM	. . . . .	R 0007
RNEB_FLO.	. . . . .	R 0004
ROFF_TIM.	. . . . .	R 0005
RON_TIM	. . . . .	R 0004
RSIL_TIM.	. . . . .	R 0006
RTEMP	. . . . .	R 0005

```

RUNNING_AVG . . . . . M 0000
RVENT . . . . . R 0006
RVENT_SIG . . . . . R 0001
SAMPLE. . . . . L 1435
SEE_LD. . . . . B 0011
SEE_PIP . . . . . B 0009
SEE_TEMP. . . . . B 0010
SEE_VENT. . . . . L 1743
SERVICE . . . . . L 156E
SET_CHGTIM. . . . . D 0019
SET_CLK . . . . . L 1413
SET_EXH . . . . . L 1117
SIL . . . . . B 0006
SPON_BR . . . . . B 0007
STRT_EXH. . . . . L 11AE
SW_OFF. . . . . L 15A1
TEMP. . . . . B 003B
TEMP_CONT . . . . . L 1573
TEMP_DEC. . . . . D 0012
TEMP_HI . . . . . I 00A0
TEMP_SET. . . . . D 0011
TEMP_STORE. . . . . D 001C
TEST0 . . . . . L 1298
TEST25. . . . . L 1286
TEST50. . . . . L 1274
TEST75. . . . . L 125B
THREE_CYCLE . . . . . D 002F
TIM_SAMP. . . . . L 13F3
TRANS_DEL . . . . . L 1625
TRANS_DEL1. . . . . L 198E
TST_BEEP1 . . . . . L 1394
TST_BEEP2 . . . . . L 13E6
TST_TEMP1 . . . . . L 1387
TST_TEMP2 . . . . . L 13D9
TST_VENTSEL1. . . . . L 1380
TST_VENTSEL2. . . . . L 13D1
TURN_OFF. . . . . L 139E
TURN_ON . . . . . L 134E
VENT_AVG. . . . . D 006C
VENT_HI . . . . . D 001B
VENT_LO . . . . . D 001A
VENT_LOW. . . . . D 006B
VENT_TBLE . . . . . L 175D
VEN_SEL . . . . . B 0004
VOL_CHG . . . . . B 0003
WAIT. . . . . B 0000

```

;%Z

00 Errors (0000)

WHAT IS CLAIMED IS:

1. A nebulizer comprising:
a housing containing a reservoir for
holding a liquid to be nebulized and an air
5 space above the reservoir for holding aerosol;
means for generating said aerosol by
nebulizing said liquid;
means for attaching said housing to a
mechanical respirator having an inhalation
10 phase, an exhalation phase, a gas flow
passageway to a patient, and an external
electrical signal source capable of generating a
first electrical signal during said exhalation
phase;
15 means responsive to said first electrical
signal for introducing said aerosol into said
gas flow passageway, such that said aerosol
fills said gas flow passageway during a portion
of said exhalation phase.
- 20 2. The nebulizer of Claim 1 further comprising
means for monitoring the amount of said aerosol
introduced into said gas flow passageway.
3. The nebulizer of Claim 1 wherein said
mechanical respirator further being capable of
25 generating a second electrical signal during said
inhalation phase.
4. The nebulizer of Claim 3 wherein said
aerosol generating means further comprising a
plurality of nebulizer nozzles each having means for
30 controlling the gas flow therethrough.

5. The nebulizer of Claim 4, wherein said introducing means further comprises:

a gas flow for directing compressed gas from a compressed gas source to each of said plurality of controlling means for said nebulizer nozzles; said gas flow means including means responsive to said first electrical signal for opening a conduit of said nebulizer nozzles and for closing the conduit to said nebulizer nozzles simultaneously or one at a time, in response to said second electrical signal.

6. The nebulizer of Claim 5 further comprising:

means responsive to said second electrical signal for generating a decreasing flow of gas; and

means for directing said decreasing flow of gas into said mechanical respirator.

7. A method of operating a nebulizer of the type having means for generating an aerosol and means for supplying said aerosol to a mechanical respirator having an inhalation phase, an exhalation phase and a gas passageway to a patient, and an external electrical signal source capable of generating a first electrical signal during said exhalation phase, method comprising:

generating said aerosol; and

introducing said aerosol into said gas passageway during a portion or all of the said exhalation phase.

8. The method of Claim 7 wherein said introducing step further comprising:

-55-

opening a valve, in response to said first signal, to introduce said aerosol from said nebulizer to said gas passageway.

5 9. The method of Claim 7 wherein said generating step further comprises:

 entraining a liquid into a source of compressed gas to generate said aerosol, in response to said first signal and continuing until standardized volume of aerosol dose has
10 been delivered.

 10. The method of Claim 7 wherein said external electrical signal source is capable of generating a second electrical signal during said inhalation phase.

15 11. The method of Claim 10 further comprising:
 ceasing the generation of said aerosol in response to said second electrical signal.

 12. A nebulizer for use with a respirator means having an inhalation phase and an exhalation phase, a
20 first tubing means connecting said respirator means with a patient wherein during said inhalation phase said respirator means is fluidically connected to said patient through said first tubing means for introducing breathing gas in said first tubing means
25 into respiratory tract of the said patient, a second tubing means connecting said respirator means with said patient wherein during said exhalation phase said respirator means is fluidically connected to said patient through said second tubing means for
30 receiving exhaled gas from said patient to said respirator means, said respirator means further

having means for generating a first electrical signal during said exhalation phase; said nebulizer comprising:

means for generating an aerosol;
5 aerosol connecting means for connecting said generating means to said first tubing means; and
means for introducing said aerosol into said first tubing means in response to and
10 synchronized with said first electrical signal.

13. The nebulizer of Claim 12 further comprising:

housing means containing a reservoir for holding a liquid to be nebulized and an air
15 space above the reservoir for holding said aerosol.

14. The nebulizer of Claim 13 wherein said aerosol connecting means connects said air space to said first tubing means.

20 15. The nebulizer of Claim 14 wherein said generating means comprising:

a plurality of nebulizing nozzles each having means for controlling the gas flow therethrough.

25 16. The nebulizer of Claim 15 wherein said respirator means for generating a second electrical signal during said inhalation phase.

30 17. The nebulizer of Claim 16 wherein said introducing means for all of said nebulizing nozzles, in response to said first electrical signal, de-

activates said controlling means, either simultaneously or one at a time.

18. The nebulizer of Claim 14 further comprising means for monitoring said aerosol introduced into said first tubing means.

19. The nebulizer of Claim 16 further comprising:

means for generating a decreasing flow of gas; and
means for directing said decreasing volume of gas into said second tubing means.

20. The nebulizer of Claim 12 wherein said means for generating said first electrical signal further comprises:

a filter pressure sensor for detecting the pressure differential in said second tubing means, and for generating a filter pressure signal in response thereto;

an airway pressure sensor for detecting the pressure in said first tubing means, and for generating an airway pressure signal in response thereto; and

means for receiving said filter pressure signal and said airway pressure signal and for generating said first electrical signal synchronized with the commencement of said exhalation phase.

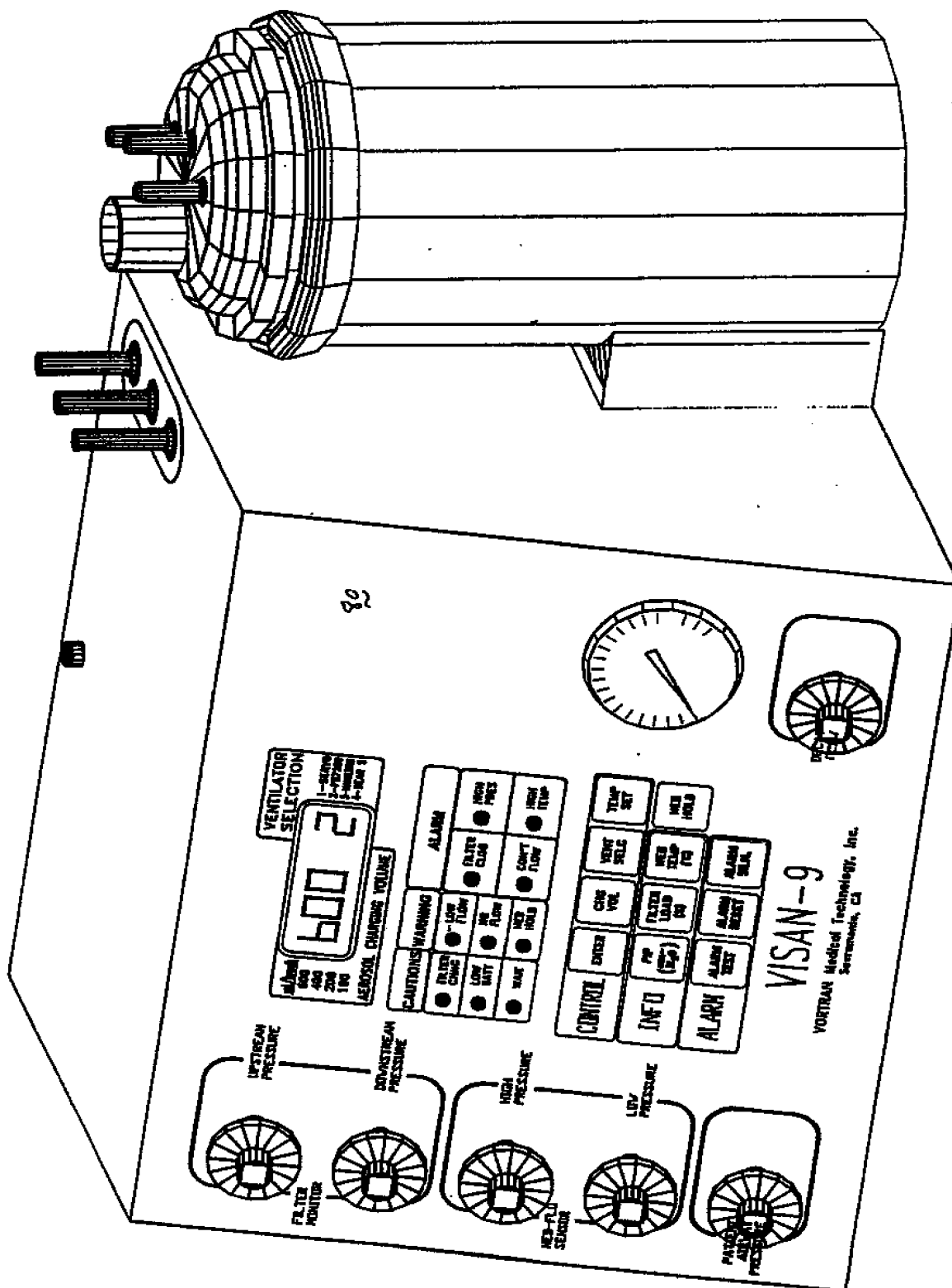



FIGURE 2

INTERNATIONAL SEARCH REPORT

International Application No. **PCT/US92/00566**

I. CLASSIFICATION OF SUBJECT MATTER (If several classification symbols apply, indicate all) ⁶		
According to International Patent Classification (IPC) -- to both National Classification and IPC I.P.C. (5): A61M 15/00, A61M 16/10, A62B 7/00, F16K 31/02 U.S. Cl. : 128/203.12, 204.21, 204.23, 204.26		
II. FIELDS SEARCHED		
Minimum Documentation Searched ⁷		
Classification System	Classification Symbols	
U.S.	128/200 14, 200.21, 203.12, 203.13, 203.14, 203.16, 203.17 203.26, 203.27, 204.17, 204.18, 204.21, 204.23, 204.26	
Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched ⁸		
III. DOCUMENTS CONSIDERED TO BE RELEVANT ⁹		
Category ⁹	Citation of Document, ¹¹ with indication, where appropriate, of the relevant passages ¹²	Relevant to Claim No. ¹³
Y	US, A, 4,106,503 (ROSENTHAL et al) 15 AUGUST 1978 See entire document	1-3,7-14,18-20
Y	US, A, 4,832,014 (PERKINS) 23 MAY 1989 See entire document	1-3,7-14,18-20
Y	US, A, 4,197,843 (BIRD) 15 APRIL 1980 See entire document	1-3,7-14,18-20
Y	US, A, RESPIRATORY THERAPY EQUIPMENT (MCPHERSON) @1985, C.V. MOSBY CO., pp. 128-131, 158-163, 468-469, 476-479 & 442-443	1-3,7-14,18-20
<div style="display: flex; justify-content: space-between;"> <div style="width: 48%;"> <p>¹⁰ Special categories of cited documents: ¹⁰</p> <p>"A" document defining the general state of the art which is not considered to be of particular relevance</p> <p>"E" earlier document but published on or after the international filing date</p> <p>"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p> </div> <div style="width: 48%;"> <p>"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</p> <p>"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step</p> <p>"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.</p> <p>"&" document member of the same patent family</p> </div> </div>		
IV. CERTIFICATION		
Date of the Actual Completion of the International Search 27 APRIL 1992		Date of Publication of the International Search Report 27 MAY 1992
International Searching Authority ISA/US		Signature of Authorized Officer  KIMBERLY L. ASHER